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ASPHYXIA NEONATORUM

The Pivot Upon Which Turns the Movement to Prevent Asphyxial Death

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OUT of a simplified method for endotracheal anesthesia, developed and described in 1927 (5), there was evolved a year and a half later, a technique for artificial respiration of the newborn. This method, described in the *Journal of the American Medical Association* (6), consisting of suction, laryngoscopy, intubation, and insufflation of oxygen and carbon dioxide under controlled pressure, was little more than an extension of the method, advocated by Meltzer in 1909 and later by Chevalier Jackson in 1913. The reviewer's contribution consisted merely in the development of simplified instrumentation for precision treatment.

The instruments—laryngoscope, insufflation tube, and pressure manometers—were designed to meet emergency use in general hospital service. All perishable parts have been eliminated and as far as possible, the equipment has been made indestructible. The armamentarium was offered as a means of carrying out, with the least possible hazard, accepted surgical principles, as they might be applied in the treatment of asphyxia of the newborn.

These principles may be stated briefly as:

Exposure of the field (laryngoscopy under direct vision)

Removal of foreign material (suction of fluid and the relief of the obstruction)

Application of treatment, directly to the damaged area with the greatest possible precision, dispatch and absence of trauma (intubation by direct vision and insufflation of oxygen carbon dioxide under controlled pressure).

Compared with the prevailing method of blind catheterization, oral suction of pharynx and esophagus (rarely trachea), followed by the manual application of an inhaler to the face of the baby, in the expectation that the gas therein will find its way past the obstruction offered by relaxed tongue, soft palate, faucial pillars, epiglottis and arytenoids, to the trachea, the method proposed proved to be all that could be desired.

By the use of the technique described the airway is easily visualized. Fluid in the field is removed under direct vision. The infant glottis is readily brought into view. The condition of the cords is noted. A lubricated metal tube of suitable size with a velvet eye is introduced without trauma; the glottic chink above the tube indicates ample space and the absence of glottic pressure. Suction of the upper trachea is easily accomplished; oxygen introduced under a pressure of 25 millimeters mercury for periods of 3 to 5 seconds promptly clears the anoxemia present.

When the respiration is completely in abeyance upon the beginning of the treatment, its return is often ushered in by very rapid, very shallow efforts which may be heard taking place through the insufflation tube. When the airway is not completely free of all obstruction, the minimal returning respiratory efforts are not observed until their cumulative effect becomes apparent in a strong effort which breaks through the prevailing obstruction. This accumulative effort seen as the initial gasp and said to precede regular respiratory efforts may not take place if the vigor of the respiratory center has been reduced by anoxemia.

To claim that such an initial respiration, either spontaneous or induced by drugs, such as alpha lobelin (15) for instance, is the natural precursor of normal respiratory effort, that it serves to clear the airway for future respiratory efforts, or that it overcomes atelectasis in any very special manner, that indeed it is anything but an evidence of existing respiratory embarrassment, is highly improbable.

When a technique is acquired and developed as the means of relieving certain definite difficulties, such as respiratory obstruction, anoxemia, central depression, the road pursued and the landmarks observed along the way are forgotten by the traveler in the satisfaction which he enjoys in arriving at his objective. He is inclined to discredit the difficulties of his approach and to stress only results. The writer admits this experience. He has been inclined to overlook the essential details of technique impressed upon him through the obligation to provide safety in the development of equipment. Having completed these safeguards, he proceeded to ignore the reason for their existence, and the obligation incumbent upon him to make these reasons clear to the uninitiated.

After an interval of 10 years, during which time students have become instructors, and since the method herein referred to has become common practice, in fact, sometimes too common to deserve note (12) it appears timely to review the use and the abuse of the technique as it has come to the attention of the reviewer.

VIEWPOINT OF THE SURGICAL DIRECTOR

The surgeon who directs resuscitation without the advice and co-operation of a competent pneumatologist (3, 4, 7, 8, 16, 17, 18, 19) faces a twofold problem: administration and research. To avoid confusion and to yield results, these problems must be sharply defined and segregated. Marshal Foch's query, "What is it exactly that you wish to do?" may well be borne in mind. The first implies the correct functioning of an accepted routine directed to a clear cut objective and based upon sound principles of pathological physiology. The second problem, research, is distinctly contributory. Its purpose is to provide improvements in routine when these improvements have been recommended by sound theory and practice.

To disregard these principles is to invite confusion and to delay real progress. A brief reflection will bring to light the frequency with which these objectives and their sequences are disregarded. The surgeon, oppressed by many demands upon his time and attention, turns the problems of routine and research to an assistant or to a technician. The latter, impatient of routine, impressed by the novelty of unsupported claims, and keen for revolutionary and mechanized technique is an easy prey to the high powered commercial approach well equipped with argument and impressive by virtue of convenient gadgets calculated to overcome all difficulties. Without the protection of a sound foundation provided by a knowledge of physiological requirements, the satisfaction of which suggest simplicity and directness of approach, there is nothing to prevent an endless procession of new equipment, much of which may actually violate basic principles in treatment. A recent communication by Yandell Henderson brings the prevalence of this situation to a focus.

BASIC PROBLEMS OF RESUSCITATION

Experience suggests that the basic problems of resuscitation are as follows: respiratory obstruction, anoxemia, and central respiratory depression.

Any technique or armamentarium by means of which respiratory obstruction may

be eliminated, oxygen brought into direct contact with the bronchial and alveolar capillaries, permitting thereby support and stimulation of the depressed respiratory center without undue trauma, provides material for a basic routine. The selection of such equipment should be based upon the degree with which it fulfills these needs. Additional claims and improvements need not be ignored but should be regarded as material for investigation and research.

Judgment passed upon equipment by the surgeon has been shown to be incomplete if limited to theoretical appraisal. The hand, the eye, and the ear of the judge must all function if the impression of a mechanical problem is to be complete. This point was impressed upon the author some years ago. An eminent authority in the field of asphyxia, entirely familiar with the theoretical aspect of the special problems involved, showed but little interest in a proposed solution. One day, however, having been induced to carry out the suggested procedures himself, he promptly adopted these as practical, personal accomplishments, entirely satisfying and readily available to others.

Routine practice in resuscitation should be carried out upon the cadaver. There is no mutilation or postmortem sign of instrumentation which interferes with subsequent autopsy findings. There is no excuse when intubation is practiced to demonstrate this upon live babies without specific pathological indications. Babies to be treated for the relief of atelectasis should be placed in the hands of the most experienced operators. Students and the newly initiated should not be permitted to practice such instrumentation.

The confirmation of a sound routine turns upon trained observation, a conviction that these observations are important and valuable, and a careful record which will bring to light the actual morbidity and mortality occurring in the relief of a given pathology.

ANATOMICAL CONSIDERATIONS

The head of a newborn baby of an average weight of 6 to 8 pounds, (2700 to 3600 grams) is about the size of a small grapefruit and weighs approximately as much. It is attached to the body by a relatively long, relatively thin neck which in the state of complete relaxation gives no support to the head. The normal baby's mouth will readily admit one finger, occasionally two. The pharynx in relaxation will admit the tip of the finger up to the attachment of the epiglottis. The distance from the gums to the glottis is about 3 inches, a relatively short distance. The distance between the epiglottis and the glottis is often so short that when the lip of the laryngoscope is placed against the epiglottis (1), it impinges against the glottis itself and obscures it. The glottic opening varies from 3 to 5 millimeters in vertical diameter and transversely at the posterior commissure is from 2 to 3 millimeters. In complete relaxation, the soft parts of the airway are collapsed and as soft and adherent as the finger of a rubber glove or a collapsed toy balloon. While insufflation tends to open these passages, suction immediately causes them to collapse still farther, simulating the phenomenon seen when one attempts to use a soft rubber tube on a suction instrument. The trachea is about 3 inches from the glottis to the bifurcation. The tracheal rings are soft and easily compressible but they maintain the lumen of the trachea under ordinary conditions. The chest wall with its intercostal muscles, accessory muscles, and the diaphragm, offer little resistance to interpulmonary gas pressure when the lungs are inflatable. When antenatal atelectasis exists, however, the resistance to expansion offered by the chest wall interferes seriously with mechanical efforts to distend alveoli by mechanical insufflation. Incidentally, this suggests pulmonary tissue resistance to pressure, entirely different from that offered by the open chest. It is, therefore, impractical to attempt to measure the fragility of the lung tissue to endotracheal pressure when the visceral pleura is not protected by the resistance of the chest wall. A pressure of 25 millimeters of mercury which may cause rupture of the alveoli in a lung removed from the chest, seldom if ever, produces evidence of trauma when applied to the lung protected by the chest wall, when the pressure so applied does not extend over a period of 5 seconds.

PHYSIOLOGICAL PATHOLOGY

A newborn baby presents one of two extremes of reflex activity and muscle tone. It is extremely important to recognize these variations as they form the criteria of treatment. There is no excuse to attempt to intubate a newborn baby whose head is moving about from the action of the muscles of the neck, or whose gums close upon the gloved finger of the operator. Asphyxia produces progressive relaxation and loss of the reflexes of the airway. In extreme asphyxia the gums separate without resistance, the tongue is completely relaxed, the soft palate and the pillars of the fauces are perfectly flaccid, the epiglottis drops into view, the glottis appears beneath the lip of the laryngoscope with cords which are silent and which are separated or in contact with one another. The mucous membranes of the field are cyanotic and injected to a degree which varies directly with the vigor of the baby's circulation. A vigorous circulation gives rise to the well known asphyxia livida, a depressed circulation on the other hand results in the so called asphyxia pallida.

Between the two extremes of active reflexes and muscle tone on the one hand, and complete disappearance of the reflexes and complete relaxation on the other, appears every variation. These variations depend upon the viability of the baby.

It is, therefore, practical and reasonable to make an immediate prognosis of the baby's condition by the state of the reflexes and muscle tone found upon the initial examination. If a baby permits the introduction of the finger into the mouth without resistance, exposure of the pharynx by the laryngoscope is indicated and will be entirely non-traumatic. If upon laryngoscopy, there is found to be active swallowing reflexes and spasm of the glottis, it will be unnecessary to intubate, for the viability present indicates that central activity will promptly result in a respiratory effort. The act of opening the mouth, lifting the tongue out of the field, and removing detritus in the airway provides adequate immediate treatment for the baby.

On the other hand if laryngoscopy reveals the pharyngeal reflex to be in abeyance and the cords inactive, the indications are to introduce a suction tube between them, to practice endotracheal suction, and to follow this by re-intubation and insufflation of oxygen carbon dioxide. In the presence of an active circulation, cyanosis which may be present upon intubation and which is seen as lividity in the mucous membranes, ecchymosis of the skin, or cyanosis of the extremities, will promptly disappear upon insufflation of oxygen. Cyanosis will be replaced by a pink color, the reflexes which are in abeyance will reappear, in accordance with the degree of viability present.

In asphyxia due to obstetrical manipulations without cerebral hemorrhage, or in respiratory obstruction from fluid in the airway, the reflexes return very promptly. However, if the asphyxia is the result of prolonged anesthesia or of medication to the mother, a longer period will elapse before the reflexes return. A vigorous circulation will promptly pick up oxygen available in the trachea and in the bronchi. A depressed circulation will react more slowly. Care must be exercised, therefore, in providing surface heat as an initial circulatory stimulation.

The rhythm of respiration is the result of a highly complex biochemical reaction which is complicated by asphyxial factors. It will vary in accordance with the freedom with which each individual respiratory effort takes place. If the airway is absolutely unobstructed as is the case when the endotracheal insufflation tube is in place, returning respiratory effort will be noted as an extremely shallow, but regular, effort occurring as rapidly or more rapidly than the pulse rate. As the vigor of the respiratory effort increases, the depth of each respiration will increase and the rate will be diminished; if the respiration is obstructed these initial efforts will be obscured until the summation results in a forceful gasp, a final effort to overcome existing obstruction. When it is realized that adequate oxygenation of the circulation may readily be carried on for hours by means of endotracheal oxygen without any respiratory efforts whatsoever, the effort to establish an artificial respiratory rate and rhythm will be of secondary importance. The objective in every case is to support the re-

turning voluntary respiration without in any way interfering with it by attempting to supplant an artificial rate and rhythm. The operator attempts, as it were, to feed the returning respiration with the oxygen which it requires to resuscitate the respiratory center.

If, however, there is no respiratory effort whatever, one is justified in attempting to initiate such effort by stimulating the Hering-Beuer reflex by the use of maximum pressure (25 mm. hg.). Following this initial stimulation, the technique described may be followed to advantage.

The return of normal vigorous respiration will be accompanied by muscular movement of the extremities and movement of the muscles of the face. The baby's head will begin to move from side to side. After normal respiration through the tracheal tube is permitted for a short period, the tube may be removed, whereupon the baby will begin to cry.

Prolonged postoperative treatment of the newborn due to drug depression or other causes when the respiration has been demonstrated to be free, is best accomplished by means of an oxygen chamber suited to the baby's size and equipped with the necessary heating and ventilating devices.

In passing, it is interesting to note that a definite diagnosis of congenital cardiac lesions or gross lesions of the circulatory system may be diagnosed by the baby's reaction to endotracheal insufflation of oxygen. The cyanotic baby is insufflated and intubated in the usual manner. If the color remains constantly dusky or fails to clear completely in the presence of endotracheal oxygen upon pressure, a portion of the circulation leaving the right heart is finding its way directly into the arterial system. We see this in a patent foramen ovale and in a congenital shortcircuiting of the large blood vessels. The reason for this phenomenon is that a definite portion of the circulating blood has failed to pass through the lungs and is contaminating the oxygenated stream. Neonatal atelectasis, cerebral trauma, as well as persistent thymus and even the rare, tracheo-esophageal fistula, fails to give this unique reaction. In each case, adequate oxygen insufflation temporarily, but completely, clears the color of the circulating blood. A tracheo-esophageal fistula may be suspected when there is a persistent long continuing discharge of fluid or froth through the glottis following satisfactory initial intubation, suction, and an apparently clear respiratory tree.

Fluid within the pulmonary airway may be expected in cesarean sections and in breech deliveries if the compression action of the uterus upon the flexed chest has not functioned to squeeze out fluid contained therein. It is, therefore, desirable to practice immediate oral, pharyngeal, and, if relaxation permits, endotracheal suction of babies delivered by these two procedures.

Operators have experienced difficulty in exposing the glottis of premature babies, insisting that the blade of the laryngoscope provided was too wide for the undersized pharynx. The author has met this situation by keeping the lip of the laryngoscope well anterior to the epiglottis, thus exposing the epiglottis and glottis simultaneously. By this technique he has used the laryngoscope for demonstration in a premature infant cadaver weighing 1½ pounds, whose head was not much larger than a lemon and whose glottis was so tiny that it was intubated by means of a nurse's hair pin.

If the infant to be resuscitated is premature, it is practical to use the tube employed for suction as an insufflation instrument. This tube is considerably smaller in diameter than is the ordinary endotracheal insufflation tube. With this technique, the suction tube is introduced into the small glottis, and suction is gently performed. The tube is then withdrawn and is attached to the insufflation tube, the mucus is blown out, and the tube is replaced as an insufflation tube.

ARMAMENTARIUM

Laryngoscope. Inasmuch as the mouth and the pharynx of the ordinary newborn will admit a finger, a laryngoscope blade limited in size to such a transverse diameter provides no embarrassment. The lamp attached is relatively large and has a long life. The length of the laryngoscope blade is such that when it is introduced to its full depth the operator's fingers, grasping the handle, contact the

baby's chin. With this contact and the contact of the baby's head lying flat upon the table, control of the field is practical. We do not practice extension of the head over a pillow, or over the edge of the table—first, because we find this unnecessary, second, because we lose control of the head, and finally, because such a procedure produces an undue extension of the neck because of the weight of the dependent head. In small babies, the laryngoscope lip remains anterior to the epiglottis; both epiglottis and glottis are brought into view simultaneously. Laryngoscopy is performed upon all babies whose relaxation is such as to permit the gums to be separated without resistance.

Suction. While suction by the operator's mouth through a catheter may be practiced with satisfaction, the double obligation of supplying the suction and directing this to an exact location is disconcerting. It is much more satisfactory to provide some source of steam, electric, or other form of suction. The tube provided for oral pharyngeal suction has a curve which fits the pharynx and terminates in a velvet tip. The degree of the suction applied should be regulated to meet the needs. Suction should not be allowed to remain in one spot, as continuous suction of the mucous membranes results in trauma.

Pharyngeal and hypopharyngeal suction should be practiced by the sterile assistant by means of a sterile suction tube immediately upon delivery of the head. When delivery has been accomplished this preliminary suction should be completed as a routine toilet, under direct vision. Provided the baby offers no resistance, endotracheal suction should be performed with a special tube having a blunt tip the diameter of which is smaller than the glottis. Endotracheal suction should be gentle and intermittent. A cough reflex which may be stirred up by the endotracheal tube is helpful in expelling bronchial mucus into the trachea, where it can be removed. We have practiced lubrication of the suction and the insufflation tube, in spite of the theoretical objection that a fat droplet might find its way into the smaller bronchi and cause a temporary block. The possible trauma inflicted by a dry tube introduced into the glottis is, we believe, more likely to be followed by ill effects than is the use of lubrication.

Insufflation tube. The measurements of the insufflation tube were secured from the cadaver. The tube is L shaped. The shorter leg of the L connects to the rubber tubing, leading to the oxygen and carbon dioxide. Near the bend of the L is a vent, by the opening and closing of which insufflated oxygen may be allowed to escape or to enter the lungs. The longer leg of the L is designed so that when it is fully introduced, the angle will impinge upon the lower gum and prevent intubation at too great a depth. This endotracheal element terminates in a shoulder about an inch and a half from the tip. This shoulder serves as a guard against excessive depth of intubation, the tip resting, when fully intubated, half the distance between the glottis and the bifurcation of the trachea. The tip is of heavy gauge metal bevelled, permitting of a velvet edge. The lumen, however, is sufficient to serve as a respiratory channel, through which the baby's voluntary respiration may take place. When this tube is introduced, a space above it and the anterior commissure of the glottis (the upper angle) are visible. Gas pressure, through the tube, is regulated by a water manometer, in the case of the hospital equipment, and by a weight, in the ambulance assembly. The water manometer is much more sensitive and indicates, in addition to the maximum pressure, variations between the minimum and the maximum, and the volume of gas delivered. When no gas is flowing, the strength of inspiratory efforts may be measured by closing the obturation valve during inspiration. The assembled equipment consists of indestructible elements with the exception of the lamp bulb and the rubber tubing which leads to the gas supply. The operator will, therefore, find the mechanism available for use even after long periods of idleness, provided the lamp and the gas supply is occasionally checked by the operating room nurse. The author has found the portable assembly (identical with the hospital model, except that the gas stand is eliminated and the water manometer replaced by a weight manometer) entirely satisfactory for

home and emergency use. He has repeatedly resuscitated patients, threatened by fatal asphyxia, with this simple equipment attaching to it the oxygen carbon dioxide tank available in the operating room. If labor is expected to take place in the home, the gas companies will deliver such a tank, thus reducing the surgeon's armamentarium to a small package.

MORBIDITY AND MORTALITY

The author has been struck by the tolerance exhibited by the infant larynx to instrumentation. He has had frequent opportunities to check at postmortem examination, the condition of the trachea and the vocal cords of babies who have been repeatedly intubated and who have died from cardiac or other lesions. While this resistance and tolerance is striking, it provides no excuse for hasty or rough manipulation. An inspection of the tiny, fragile structures making up the baby's airway impresses one immediately with the need of thoughtful care and of deliberate gentle manipulation. Looked upon from a statistical point of view, it is surprising to find the absence of morbidity and trauma even in the hands of the casual, partially instructed operator. The article by Dr. McGrath and Dr. Kuder, brings out this fact in a striking manner. The new edition of Williams' *Obstetrics*, edited by Dr. Stander, and a later article by Marchetti, confirm this early impression.

The use of intubation in conjunction with negative pressure cabinet treatment, so called iron lung, is an important factor in the early care of these patients.

ATELECTASIS

The problem of antenatal and postnatal atelectasis is wide open for investigation. We have found to our disappointment that many babies insufflated come to autopsy showing extensive antenatal atelectasis. These lungs when removed from the chest and insufflated with a very low pressure of gas, promptly become distended and fully aerated. It would appear that the resistance offered by the chest walls and the diaphragm to the parietal surface of the infant lung in some way prevents the brief insufflation employed from finding its way into the smaller air vesicles. In accordance with advice received from Dr. Chevalier Jackson it is the author's practice to limit the insufflation period to 5 seconds. Since this pressure must be transmitted through a system of tubes of decreasing diameter, the resistance offered thereby becomes so great that by the time the finer radicals are penetrated, all pressure has disappeared. It has been stated that the initiation of the respiration by intravenous stimulation (15) is followed by relief of atelectasis. This claim is not accompanied by the only evidence of proof available, namely, comparative fluoroscopy and roentgenography before and after treatment, combined with volumetric mensuration of the respiratory tidal capacity. It is possible that much light on the problem of atelectasis might be brought to bear if a series of normal babies might be subjected to fluoroscopic and roentgenographic examination immediately upon birth. Insufflation of oxygen under measured pressure, performed under fluoroscopic control, recorded by roentgen-ray, would enable one to see the illumination of the atelectasis as it occurs and measure its extent.

Full term, normal babies may be subjected to examination with the laryngoscope, without trauma several days after birth, and insufflated with oxygen under measured pressure for the relief of persistent cyanosis. In the insertion of the tube under these conditions, one must be familiar with the field—an accomplishment which may be achieved without great difficulty. A number of babies, so insufflated, appear to have been relieved of cyanosis and atelectasis (1). We are not satisfied, however, with the consistency of these results.

THEORETICAL CONSIDERATIONS AND RESEARCH

The work of Rosenfeld and Snyder in which the intra-uterine respiratory movements of the rabbit fetus were observed is extremely interesting and suggestive. In the light of the reviewer's experience with the character of the newly established respiration of the newborn through an absolutely patent airway, the following hypothesis, part of which is suggested by Eastman's excellent article, invites

consideration as a logical transition from intra-uterine to extra-uterine life without imposing the necessity of a dramatic alteration in respiratory physiology.

Let us consider the fetus as a fish, suspended in fluid, exerting an equal pressure over the surface of its body and within its open body cavities. Respiratory movement takes place causing a gentle circulation of fluid from the amniotic bath in which the child is suspended, through the mouth and into the trachea. These movements, the precursors of those to occur in extra-uterine life, accomplish the end of maintaining the patency of the airway to fluid as well as synchronizing and developing the respiratory musculature. Adequate oxygenation is provided by the placental circulation. At birth, by vertex delivery, intra-uterine pressure compresses the chest and upper airway, squeezing much of the fluid present out of the mouth and nostrils. This preparation for an atmospheric environment is accompanied by varying degrees of respiratory obstruction. If the baby is vigorous and awake as it were, that is if he is not under the influence of an anesthetic which has been administered to produce general anesthesia, basal anesthesia or asphyxiation (profound anesthesia), muscle tone and active reflexes help to keep open and clear the airway for the extra-uterine respiratory effort. This effort, the accumulative effect of many repressed efforts, finally breaks through the existing obstruction and initiates subsequent rhythm. If the baby presents profound relaxation, obstruction, and respiratory depression, these complications must be relieved or he will die. As expansion of the lung gradually takes place, this becomes evident in an increased tidal capacity which conversely might well be made the measure of respiratory progress. Premature infants by virtue of their immaturity present incomplete developments of terminal alveoli which is evidenced in varying degrees of antenatal atelectasis.

The practical results of the technique developed and described herein proved so satisfying that the author felt an obligation to offer this wherever it might prove of value. In the course of numerous addresses delivered to staff conferences, the question arose as to the similarity between asphyxia neonatorum and the asphyxia occurring in submersion, carbon monoxide poisoning, and other conditions requiring artificial respiration. It occurred to the reviewer that asphyxia was in reality a generic terminology, the specific instances of which were found in the many conditions bringing about acute asphyxiation frequently resulting in death. The test for such asphyxial death turned upon the reaction to artificial respiration. If artificial respiration was calculated to result in the saving of the life of the patient, the asphyxia was considered as an etiological cause of the generic condition. If the treatment of asphyxia, however, might be said to have no effect upon the course of the fatal condition—as in the case of septicemia, acute infectious diseases—this was not considered as an asphyxial death.

At the suggestion of Dr. Alexis Carrel, the vital statistics for New York City, covering the causes of asphyxial death noted were examined, and it was found that the total mortality from this cause exceeded 50,000 lives a year. As a result of these findings a Society for the Prevention of Asphyxial Death was incorporated in the spring of 1933, and through the courtesy of the New York Academy of Medicine, a one day's conference on the problem of asphyxia took place May 24, 1933. The importance of this gathering may be gathered from the speakers on the program: L. R. Williams, Shirley W. Wynne, H. P. Martland, Haven Emerson, T. A. Gonzales, D. J. Donovan, Chevalier Jackson, C. J. Imperatori, Yandell Henderson, D. J. Edwards, E. B. Piper, H. J. Stander, P. N. Coryllos, H. B. Williams, John F. McGrath, Mr. W. A. Whitney, and Mr. Leon Senior (3). Later in the same year, an exhibit on asphyxia was set up at the Century of Progress in Chicago. In the course of these public activities which drew their origin directly from the successful results of resuscitation of the newborn, there accumulated experience to indicate that the technique described for asphyxia neonatorum by a simple adaptation of instruments, met the obligations presented by adult asphyxia in its many fields.

In the winter of 1934, a second conference covering a two day session, took place at the

Hotel Biltmore, New York City (14). This conference, complicated by a printer's strike and synchronizing with the blizzard of February of that year, once more drew a notable assembly of speakers, including: J. J. Walsh, H. H. Forbes, P. N. Coryllos, H. B. Williams, C. H. Watson, Charles Norris, H. W. Neail, H. P. Martland. A. O. Gettler, W. C. Phillips, Colonel C. R. Reynolds, D. P. Murphy, P. A. Harper, J. D. Kernan, R. R. Sayers, H. H. Globus, Major Leon A. Fox, L. H. Bauer, E. W. Brown, M. H. Foster, C. G. Heyd, W. P. Northrup, Jr., Mr. Robert P. MacFadden, Mr. L. T. White, and Colonel F. L. Devereux. Later in the spring, a symposium on asphyxia took place at the annual meeting of the Medical Society of the State of New York. At this meeting, the idea of integrating anesthesia, resuscitation, and oxygen therapy as gas therapy was proposed by the speakers, Drs. Jackson, Barach, and Flagg.

The aims and purposes of the Society for the Prevention of Asphyxial Death were approved by the Medical Society of New York State on May 14, 1934, and by the house of delegates of the American Medical Association on June 12 of the same year.

In the spring of 1935, the society was invited to co-operate with the City in June. This exhibit set up by C. I.. Jackson and Harrison Martland finally materialized as a full section of fourteen booths demonstrating many of the more prominent forms of asphyxiation. In this exhibit, that on asphyxia neonatorum prepared by the obstetrical department of the New York Lying-In Hospital enjoyed a prominent place. In the Spring of 1936, upon a motion from the delegate of New York State Medical Society, the appointment of a committee on asphyxia of the American Medical Association was authorized. On October 6 of the same year, the committee was named and held its first meeting in Chicago in December of that year. The report of this committee appears in the *Journal of the American Medical Association* for May 1, 1937, p. 1531. The report of the committee suggests the following specific causes of the generic problem of asphyxia.

1. Asphyxia neonatorum.
2. Asphyxia from gases, used industrially: (a) carbon monoxide from illuminating gas and from engine exhaust; (b) refrigerants such as ammonia, carbon dioxide, and dry ice; (c) fumes in the manufacture of chemicals; (d) gases associated with the oil industry; (e) gases in the mining industry; (f) fumigation for disease, the destruction of rodents on board ship and elsewhere.
3. Asphyxia from gases in warfare.
4. Asphyxia from drugs, hypnotics, narcotics, and sedatives, including acute alcoholism.
5. Asphyxia from disease, such as acute pulmonary conditions, asthma, and cardiac decompensation.
6. Asphyxia from developmental and mechanical abnormalities, such as neonatal atelectasis and collapse of the lung.
7. Asphyxia from anesthesia due to overdosage, idiosyncrasy or a failure to meet mechanical obstruction, occurring in relaxation.
8. Asphyxia from drowning (submersion).
9. Asphyxia from flying at high altitudes.
10. Asphyxia from fire fighting (smoke, chemical poisoning).
11. Asphyxia from obstruction by foreign bodies (a) material caught in the esophagus or inhaled; (b) tumors or infections within or without the airway.
12. Asphyxia from strangulation.
13. Asphyxia from electrocution.
14. Asphyxia from allergy.
15. Asphyxia from terminal poliomyelitis.

This brief résumé of the evolution of asphyxia neonatorum serves to indicate the importance which may be attached to the prevention of asphyxia in this field. Asphyxia in the newborn according to the figures now available suggests that more than 60 per cent of all asphyxial deaths may be attributed to this cause. Asphyxia neonatorum presents the unique distinction of occurring under ideal conditions for treatment. Preparation to care for the asphyxiated patient may be completed and the patient may receive treatment immediately upon delivery. There is no long interval between the accident and the treatment as in the case of submersion, carbon monoxide poisoning, and other asphyxia accidents. For this reason the importance of establishing generally accepted principles covering the routine treatment of asphyxia neonatorum can scarcely be overestimated. This treatment radiates through the entire field of asphyxial treatment.

CONCLUSIONS

The physician who treats asphyxia neonatorum should acquaint himself with the

anatomy and the physiological pathology of the baby's airway. Treatment should follow recognized surgical principles whenever conditions permit, i.e., exposure of the field, treatment under direct vision.

The surgical director will find it helpful to set up a routine designed to meet accepted surgical principles of treatment in the simplest manner possible.

If the condition calls for instrumentation, this should be practiced up to the limit of the benefits secured. It should be clearly understood that resuscitation apparatus is merely a means to an end. Anatomical, physiological, and pathological complications occurring in asphyxia. contra-indicate the use of so called automatic apparatus—nothing can take the place of the intelligent application of simple instrumentation. The situation is too involved to hope for the best results without suitable theoretical training and practical experience. Every clinic cannot be an experimental laboratory. Properly directed research is and always has been the means of introducing new procedures. but special training is required in order that judgment passed upon any practice may have value.

The reviewer's clinical experience in his attempt to carry out recognized principles is rehearsed from the point of view of the field as well as the armamentarium. Unusual conditions are discussed at some length. The need for research into the problem of atelectasis is stressed and a method of approach is suggested.

The importance of asphyxia neonatorum, as it bears upon the entire field of asphyxia, is emphasized. A brief résumé is made to indicate that asphyxia of the newborn is the pivot upon which turns the present movement to prevent asphyxial death.

As a means of attacking the problem in a comprehensive manner, it is proposed that large clinics establish a department of pneumatology to control the use of gases employed for therapeutic purposes.

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OSTEOLYTIC OSTEOGENIC SARCOMA WITH A REPORT OF EIGHT FIVE-YEAR SURVIVALS

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OSTEOLYTIC sarcoma of bone, because of its pulsating character and extreme vascularity and because of the hemorrhage and formation of new blood vessels seen under the microscope, was formerly regarded as an aneurism of bone. These features of the tumor are still aids in the diagnosis, although more than 50 years ago Sir James Paget voiced the opinion that the so called bone aneurism was essentially a tumor of bone. In more recent years, pathologists and surgeons as well have frequently referred to the tumor as a large round cell sarcoma.

Geschickter and Copeland have related the histogenesis of osteolytic sarcoma to the growth processes occurring in the skeleton subsequent to chondrification, explaining the failure of the tumor to form bone on the type and location of the tissue from which it arises. They consider the tissue of origin to be endosteum. This membrane takes part in the resorption of calcified cartilage and forms cancellous bone, and there is a marked similarity between the microscopic features of osteolytic sarcoma and that of ossification of the diaphysis in human embryos of 120 to 140 millimeters. The normal embryo, however, contains an abundance of calcified cartilage which supplies adequate amounts of mineral for subsequent ossification. This supply of calcium salts is not present to the same extent in individuals with osteolytic sarcoma, and so the formation of preosseous tumor tissue is out of all proportion to the formation of bone. That osteolytic sarcoma is definitely osteogenic is borne out by the formation of bone in pulmonary metastatic nodules. It is a tumor of very primitive tissue and, as in the case of all tumors of similar nature, it has an unusually rapid growth and very malignant characteristics.

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The systemic findings, such as elevation in temperature, increase in pulse rate, and rise in total white blood cell count are similar to those of osteogenic sarcoma in general. The pulse rate is sometimes increased out of proportion to the temperature, the increase in rate probably being due to toxicity from the tumor. With the advanced cases there is an anemia proportionate to the stage of the disease. Some patients present a marked loss of weight early in the course of the disease, and this is probably produced by the pain, loss of sleep, anxiety, and the resultant anorexia. Following amputation of the affected limb such patients often show rapid gain in weight.

The boggy and indurated feeling when the tumor is palpated is the result of subcutaneous edema and hemorrhage. The pulsation sometimes observed is produced by a large cavity in the bone, erosion of the cortex and extreme vascularity, so that the tumor is expansile with each systole. This vascularity, as mentioned previously, is an aid in the diagnosis of the tumor. Many surgeons at exploration of osteolytic sarcoma have met with almost uncontrollable hemorrhage. Blood or blood stained fluid is a frequent manifestation of this form of sarcoma whether in the primary tumor or in the fluid aspirated from the pleural cavity in metastatic lesions. The presence or absence of soft tissue swelling is dependent upon the amount of extension of the tumor through the broken cortex.

The characteristic roentgenological finding is a lytic process. The destruction usually produces in the early stages a moth eaten appearance because of the interposition of areas of normal density among the areas of rarefaction produced by the tumor tissue. The growth may be located centrally or just beneath the cortex; and with progress of the disease there results a periosteal reaction which may be manifested by lipping, fuzziness, or by splitting and interruption of the continuity of

the periosteum. These findings are aids to the roentgenological diagnosis. It should be remembered that osteolytic sarcoma may simulate in the x-ray films the changes produced by giant cell tumor, bone cyst, metastatic hypernephroma, and metastatic carcinoma, though this is not the usual finding. Pathological fracture is common in osteolytic sarcoma occuring in weight bearing bones because of the rapidity of growth and the accompanying destruction of bone. Even moderate use of an affected limb during the development of the lesion predisposes to pathological fracture.

The tumor in the gross is most often hemorrhagic, friable, and contains some white fibrous tissue. It may resemble the tissue of giant cell tumor. Microscopically the predominant cells are large round cells and long, oval or spindle cells with an abundance of chromatin material in the nucleus. Extremely bizarre nuclei may be produced during the stages of mitosis. Tumor giant cells with coalescence of two or more nuclei are frequently seen. These nuclear changes in the cells and their variations in shape indicate the primitive nature and anaplastic property of the tumor. Large and small giant cells of the epulis type are present, and the number of nuclei may range from two to one hundred. Giant cells with few nuclei are more common. Geschickter and Copeland have referred to the typical plump or large spindle like cell as an "abortive osteoblast." Collagenous or connective tissue material in various types of arrangement constitutes the stroma. Bone spicules and areas of osteoid tissue are less commonly found. Hemorrhage, both as an extravasation of the red blood cells and as pools not enclosed by endothelial cells, is a frequent finding.

In the entire group of 131 cases of osteolytic sarcoma recorded in the Surgical Pathological Laboratory of the Johns Hopkins Hospital there was a total of 117 cases in which the age was recorded. Fifty-six, or 47 per cent, were from 11 to 20 years of age with an average age of 16 years. Approximately 16 per cent of the cases were from 21 to 30 and 8.5 per cent were in each of the next three decades. Only one case was under the age of 10. Seven were over the age of 60. There were 543 cases of osteogenic sarcoma of all types recorded in this laboratory, osteolytic sarcoma representing 24.1 per cent of the entire group.

The bones most often involved in this series were in their order of frequency: lower femur, upper tibia, pelvis, humerus, middle femur, and lower tibia. In 46 per cent of the cases, the bones about the knee joint were involved. Trauma was a factor in the history of many cases, but the time interval and the severity of the injury were so inconsistent that no conclusions can be drawn.

In the present study the results of treatment in 131 cases of osteolytic sarcoma have been analyzed. Among these cases were 11 patients who lived longer than 5 years after treatment was instituted. Three of these cases formerly held to be osteolytic sarcoma were excluded because two had a marked resemblance to sarcoma of nerve sheath and the other presented the histological structure of synovial sarcoma. These cases were alive, 11, 10, and 28 years after radical resection or amputation, and all of them consisted of a destructive lesion in the involved bone. The 8 remaining cases are reported in this article, with an analysis of their clinical and pathological features.

Of 99 cases followed for a period of 5 years, 8 were alive at the end of the 5 year period. Of the 8 cases, 5 lived approximately 10 years or longer, and 3 died with metastasis at 6, 7, and 7¼ years, respectively, after operation. In all, 92 per cent died from the effects of the tumor prior to 5 years, and 94 per cent died within 8 years. The average duration of life after the primary treatment was 10.3 months in the patients dying within 5 years. If the patient lived for as long as 4 years after the amputation or radical resection, the prognosis for permanent survival was much better. The 5 year period can be regarded as only an arbitrary measure of survivals adopted for malignant conditions in general. Three per cent of the patients died as a result of the disease after 5 and under 8 years.

Osteolytic sarcoma occasionally arises in a benign giant cell tumor, and this may account for the reports that some giant cell tumors metastasize fatally. It is well known that osteolytic osteogenic sarcoma is a tumor that

varies in its clinical, roentgenological, and pathological features. In the review of the surviving cases presented here, particular care has been used in the microscopic classification. This was desirable since the clinical features of some of the living patients are slightly different than that expected in this type of tumor. Six of the patients had from one to four operative procedures prior to amputation. This finding in cured or arrested cases of sarcoma of bone has been reported by others, and would suggest in itself that the condition was less malignant. However, microscopic examination showed a highly malignant appearance in 6 of the survivals and none showed histologically borderline features between a benign and malignant condition. None of the cases except Case 7 (Path. No. 32663), presented from every angle the classical picture of osteolytic sarcoma.

Six of the patients were over the age of 19. In 4 cases the tumor was considered to develop as a primary lesion, and in 4 cases as a secondary lesion. In 2 cases the lesion probably developed at the site of giant cell tumor, and one possibly at the site of a cyst. The other secondary lesion developed in an individual complaining of arthritic symptoms for many years. One patient lived only 5 years and 9 months after amputation, and developed symptoms of metastasis in the chest 3 years prior to death. The metastatic area was kept under control by deep x-ray therapy. The reasonably comfortable prolongation of this patient's life is a recommendation for palliative deep x-ray therapy for pulmonary metastasis.

The methods of treatment in the cases studied do not allow any new suggestions for therapy. Primary amputation well above the location of the tumor, or radical resection if the case allows such a procedure, as soon as the diagnosis is confirmed is still the treatment of choice. The fact that minute deposits of tumor tissue are often present in the marrow spaces at some distance from the gross lesion accounts for the frequent recurrence in the amputation stump. It is supposed that metastasis occurs from continual small emboli of tumor cells in the pulmonary tissue until there is a successful transplant. Why metastasis occurs up to 7 years after the amputation has not been satisfactorily explained. Whether the tissue is dormant in the chest or in some bone other than that involved originally or whether there is an additional occurrence of the tumor is a matter of conjecture. Though metastasis may occur in lymph nodes, in other soft tissue and in other parts of the skeleton, it is not common.

Some individuals hold that if the patient survived, the lesion was not a sarcoma of bone. Advocation of this view will not help to lower the mortality in osteogenic sarcoma. A study of a large series of osteolytic sarcomas leads to the opinion that patients with more or less atypical lesions are the ones most likely to survive. The time elapsing before treatment is instituted for osteolytic sarcoma has a definite bearing on prognosis, notwithstanding the exceptional features of some of these cases in which patients have survived the 5 year period. In the past few years, rapid strides have been made in the early diagnosis of tumors of bone, but there probably has not been an accompanying increase in the rapidity with which sound and adequate treatment has been instituted.

CASE 1. Path. No. 10602. A white male, aged 30 years, injured his right shoulder in 1908 and had symptoms in this region until December, 1909, when a wrench of the arm fractured the upper humerus. Five months later there was a painful swelling at this site, and roentgenograms showed bone destruction above an oblique fracture. The tumor was curetted in May, July, August, and October, 1910. Coley's toxins were given and continued after an amputation through the shoulder joint was performed in 1911. In April, 1912 there was an amputation of the shoulder girdle for recurrence under the clavicle. Six years later the chest wall was invaded by tumor. The recurrence was treated with radium but the patient died with pulmonary metastasis 7 years after the second amputation. This was over 8 years after the primary treatment. The sections from the first operation have been lost. The pathological report describes a tumor composed of spindle and round cells with a large amount of hemorrhage. Huge round cells with malignant nuclei were present in the sections examined from the second operation.

CASE 2. Path. No. 14229. A white woman, aged 61 years, had pain and tenderness about the lower end of the right femur for 10 years. In May, 1913, she had an exacerbation of symptoms. The knee was flexed, motion was limited, and there was enlargement of the lower thigh with some distention of the knee

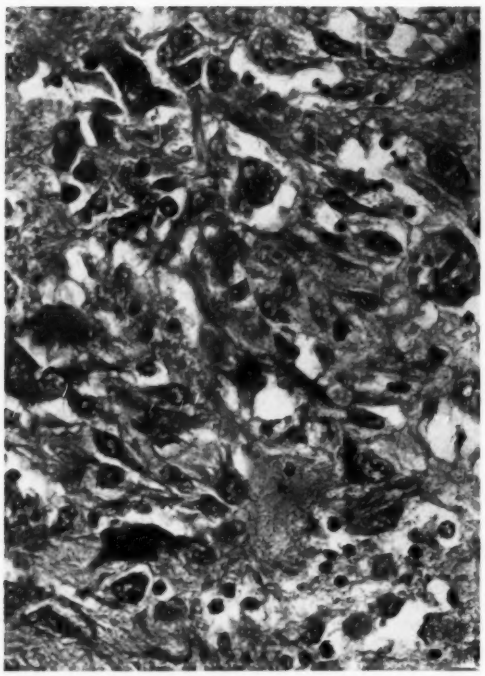

Fig. 1. Case 2. Path. No. 14229. Photomicrograph of tissue obtained at amputation in 1913. The large vesicular nuclei and tumor giant cells indicate the malignant character of the tumor. The patient died of old age 11 years after amputation.

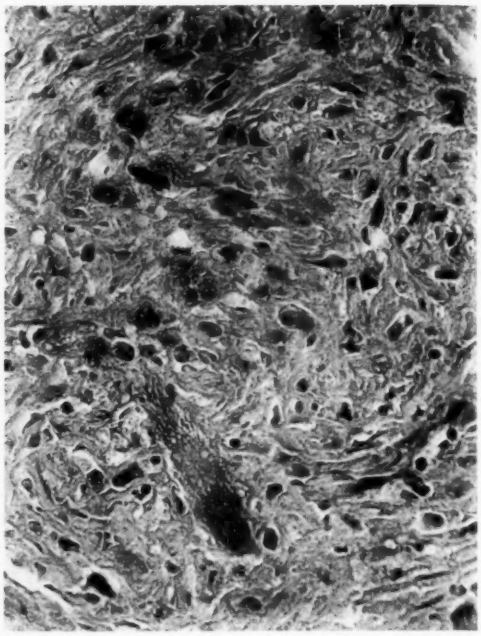

Fig. 2. Case 4. Path. No. 27908. Photomicrograph showing fibrous character of the stroma. The nuclei of the cells are large, hyperchromatic and show frequent mitosis. Amputation in 1921; last reported well in 1931.

joint. Roentgenograms showed an enlargement of the lower end of the femur with rarefied areas in the marrow cavity that extended into the condyles of the femur. It resembled to some extent the appearance of a giant cell tumor. In June, 1913, the knee joint was explored and, upon finding bloody fluid in the joint that came through a crack in the cartilage of the lower femur, the wound was closed, and amputation was performed through the upper third of the thigh. Both condyles were filled with a blood clot. Between there was soft, white tumor tissue. Bone destruction was marked. Microscopic examination showed typical osteolytic sarcoma. There were epulis giant cells, tumor giant cells and long oval cells containing enlarged nuclei with much chromatin material. Marked malignancy was shown by the variation in nuclear structure (Fig. 1). The patient died of old age, 11 years and 2 months after the amputation, with no suggestion of recurrence or metastasis.

Case 3. Path. No. 26877. This was a white male, aged 30 years, who was seen by the surgeon referring the case to this laboratory in 1920. He gave the following history. In 1916 irregular attacks of pain occurred in the right knee and, 6 months later the knee was explored for internal derangement. The only positive finding was a congestion of the synovial membrane. He continued with symptoms while having "Neisser" serum and physiotherapy until 1920, when roentgenograms showed osteomyelitis or cyst formation of the upper end of the tibia. The tibia was opened and a gauze pack was left in. About 1 month later roentgenograms showed regeneration in the area of the removed bone and gave the examiner the impression that the process was osteomyelitis. After a report on the section from the exploratory operation, amputation was performed November 22, 1920. The patient was last reported well 17 years later on August 21, 1937. Sections were interpreted as sarcoma of the fibrospindle cell variety. The sections available for study today are not perfect. However, they are unquestionably sarcoma. Heavy collagenous fibers indicate that it is more definitely of the fibrospindle cell group. The osteoblasts are small and there are frequent mitotic figures.

Case 4. Path. No. 27908. A colored male, aged 43 years, came under observation complaining of a knot in the lower left leg. The enlargement developed shortly after a severe blow 18 months previously. Three months before hospitalization, the

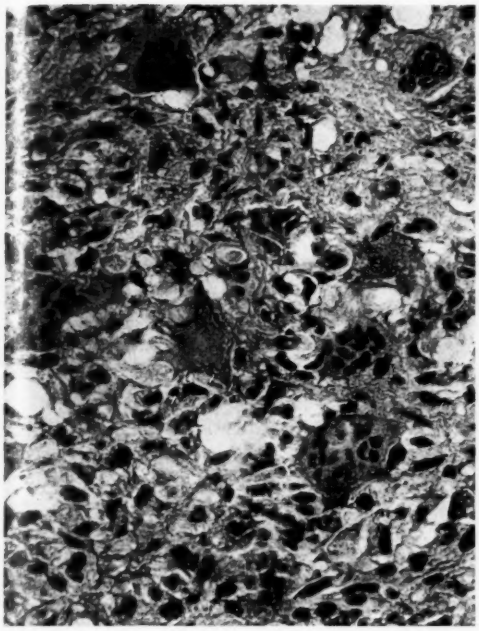

Fig. 3. Case 5. Path. No. 29327. Photomicrograph showing giant cells of epulis type. The cells of the stroma show enlarged hyperchromatic nuclei. The malignant features of the tumor were less at the first operation. Patient is well 15 years after amputation.

swelling had developed to such an extent that it formed a collar around the leg and he had lost 7 pounds in weight. There was an increase in local temperature and the tumor was fluctuant. It did not pulsate. The highest temperature prior to operation was 101 degrees with a pulse rate of 120. The roentgenographic report was a marked destruction in the lower end of the tibia with periosteal bone proliferation and soft tissue swelling. Amputation was performed. The gross specimen showed marked destruction of the tibia. The tumor tissue was soft and extended upward in the marrow cavity. There was some bone formation among the débris of destroyed bone. The sections showed round and spindle cells in various sizes and shapes and many tumor giant cells (Fig. 2). The patient was last reported well in 1931, 10 years after the amputation performed in 1921.

Case 5. Path. No. 29327. A white male, aged 19 years, had pain about the left knee in June, 1920. He gradually became worse and in October, 1920, the area was incised, but no pus was found. The wound became infected and drained for 4 months. A short time later a roentgenogram showed a large cavity in the lower end of the femur. In November, 1921, the femur was opened. The cavity contained a

Fig. 4. Case 6. Path. No. 31890. Low power photomicrograph showing malignant spindle cell character and large amount of osteoid material from the pulmonary nodule obtained at autopsy 7 years after amputation.

distinct wall and a large amount of blood was evacuated. The cavity was cauterized and the wound closed. The wound healed *per primam*. The pathological report was "giant cell sarcoma." On April 29, 1922, the tumor had recurred and was growing very rapidly. Roentgenograms showed destruction of bone. A mid thigh amputation was performed well above the growth, and examination of the sections showed large and small epulis giant cells, tumor giant cells, hemorrhage, spindle and large round cells (Fig. 3). The tissue had a much more malignant appearance than that obtained at the previous operation. The patient was reported well 15 years after the amputation.

Case 6. Path. No. 31890. A white male, aged 35 years, was seen in 1908. He gave a history of pain and swelling at the lower end of the femur of 7 months' duration. Roentgenograms showed a central destructive lesion of the tibia. The lesion was curetted and the microscopic report was giant cell tumor. There was a recurrence 13 months after the curettement, and the leg was amputated. The patient died 7 years after the amputation with metastasis in the lungs. The only sections available are from the metastatic nodule, and show both fibroblasts and osteoblasts with many giant cells of the epulis type. There is a great deal of osteoid material. Many of the cells have a malignant appearance (Fig. 4).

Case 7. Path. No. 32663. A white male, aged 20 years, came under observation with a history of pain in the left upper arm followed by soreness and loss of

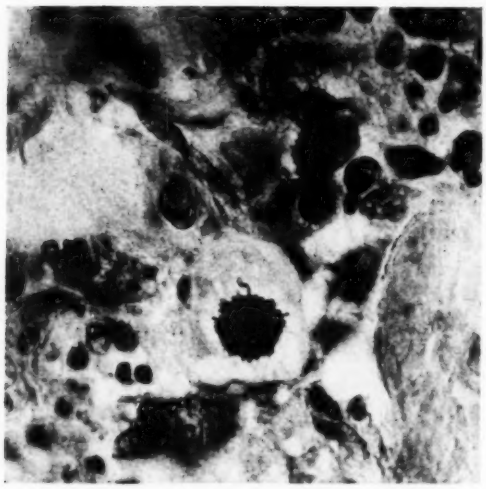

Fig. 5. Case 8. Path. No. 41194. High power photomicrograph showing marked evidence of malignancy. Note the bizarre nucleus. Patient well 8 years after radical treatment.

function. Two months prior to his admission to the hospital in December, 1922, he had fallen and fractured the humerus. Upon admission, roentgenograms showed a fracture of the surgical neck with many areas of rarefaction. The arm was explored and tissue thought to be inflammatory was removed. In January of 1923 swelling and induration of the arm were noted. The condition became progressively worse and a shoulder joint amputation was performed on March 17, 1923. Sections from the tumor showed typical osteolytic sarcoma with fibroblasts, osteoblasts, and numerous tumor giant cells. Some osteoid tissue and bone formation were noted with adjoining areas of cartilage. There were giant cells with few to many nuclei. The patient developed metastasis in the chest in 1925, but lived 3 years longer. At death, 5 years and 9 months after amputation, he was thought to have metastasis in the pelvis also but this was not verified.

CASE 8. Path. No. 41194. This was a male aged 14 years, who gave a history of striking his left leg severely 3 weeks before examination. There was moderate swelling soon after. Examination showed a fusiform swelling at the upper end of the left tibia. The tissue was dense and boggy to palpation and there was a slight increase in local heat. The leg was immobilized in extension and pain was lessened. Roentgenograms showed a destructive process involving the inner half of the tibia at its upper end, limited by the epiphyseal line. The cortex was destroyed. The area was explored on the assumption that the process was an infectious one. The tissue found in the destroyed bone could be wiped away with a sponge. The walls of the cavity were irregular, and there was a moderate amount of hemorrhage. The area was cauterized and packed. Later massive doses of radium were placed in the cavity and deep x-ray therapy was given over the groin and pelvis. The maximum temperature prior to the operation was 100.2 degrees with a pulse rate of 90 to 120. He had at times a pulse rate of 120 with a normal temperature. The leg was amputated on June 1, 1929, 6 months after the first operation. The cavity was rather extensively infected, and there was no evidence of tumor tissue. Sections made from the material removed at the first operation show a great deal of hemorrhage. The tumor cells are variable in size and shape, most of them being large and round or oval cells. Bizarre nuclei are present and some osteoid material is seen (Fig. 5). The patient is well today, 8 years after the first operation.

It will be noted in this series of cases of osteolytic sarcomas with survival of more than 5 years after treatment that half of the cases occurred in the second decade of life and only 2 patients were under the age of 20. Several of the 5 year survivals had one or more operative procedures prior to amputation, but in all radical surgery was ultimately instituted. The microscopic findings in some cases were suggestive of a higher degree of malignancy than was to be expected from the duration of symptoms and roentgenological appearances. Five year survivals are less likely in the primary tumors of young individuals, with a brief duration of symptoms.

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APPENDICITIS IN CHILDHOOD

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JUST fifty years ago Reginald Fitz published a remarkable monograph on the treatment of inflammation of the vermiform appendix. Since that time the literature has been filled with articles on the subject, but surprisingly little can be added to the conclusions he reached, even today after all the statistical, pathological, and bacteriological studies which have accumulated since then. I hesitate to add anything to this deluge of articles which has flooded the medical journals, but after 50 years just as many people are dying of appendicitis as ever; in fact, there are good reasons to believe that more people die each year of this disease than did 30 years ago. Walker made a study of the available vital statistics and hospital records and concluded that while in the better hospitals the operative mortality was decreasing, the mortality per 100,000 of population is increasing. It is estimated that in the United States alone 20,000 persons die annually of appendicitis. This condition is a disgrace to the medical profession and until it is corrected we must not for a moment allow interest to lapse in the early diagnosis and proper treatment of the disease. We must not, as we might easily do, shift the blame to an ignorant laity who will not consult their physicians early but wait until the effects of ice bag, cathartic, and time have been tried and the golden opportunity for a simple, safe, and easy cure has passed. The attitude of the laity is largely our fault, and we should keep hammering at laity and profession alike for early diagnosis and treatment.

Dissatisfaction with the present conditions has manifested itself in recent years, by a tendency to departure from the old dictum to operate as soon as the diagnosis has been made. Numerous surgeons in this country and abroad have advocated a return to Ochsner's method of treating the late cases complicated by peritonitis. We have carefully reviewed our cases at Babies Hospital during the five years 1930–35 and have reviewed the recent literature to determine if we should change our policy of early operation.

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AGE AND SEX

For some reason appendicitis is much more common among boys than among girls. No satisfactory explanation of this fact has been advanced. In this series the preponderance is not as marked as in most others, where it is in the neighborhood of two to one. Of our 220 cases 124 were boys and 96 girls. Beekman had 91 males to 54 females. The mortality is usually reported to be higher in females.

No age is immune to appendicitis, cases having been reported in which perforation occurred *in utero;* however, the disease is very rare before the age of two. In 1916 Abt could find only 80 cases in patients less than 2 years old. Just why there should be such a marked difference in the incidence of appendicitis before and after the age of 2 no one knows, but the change to a solid diet and assumption of the erect posture probably influences it. The fact that we had 12 cases in 5 years indicates that it is more common than is usually supposed and that the diagnosis is frequently missed. After 2 years, there is a steady increase in the incidence until the second decade when it reaches the maximum. The age incidence in Beekman's, Woodall's, and our own series is shown in Chart I.

PATHOLOGY

Appendicitis is not a specific disease entity. There are numerous precipitating factors and almost any organism may be encountered. In children, as in adults, the vast majority show some mechanical block to the lumen of the appendix. This is most frequently a fecal concretion, but may be an angulation or fibrotic obliteration of the lumen. However, there is not necessarily a mechanical factor. The intact mucosa is not impervious to invasion by pathogenic organisms, and the large amount

TABLE I.

Author	Number cases	Pain		Vomiting	
		% Present	% First symptom	% Present	% First symptom
Caldwell	220	99	77	88	11
Beekman	145	100		90	
Stone	258	100	97	86	3
Mueller	58	100		73	
Maes	250	100	90		6

of lymphoid tissue in the appendix in children make it especially vulnerable to attack.

The pathology in no 2 cases is exactly alike and we believe the simplest classification is the best. We have included no cases of "chronic," "recurrent," "subacute," or "catarrhal," appendicitis, since interpretation of such terms varies so much that they are practically meaningless. We have confined ourselves to three groups: (1) *acute*—acute inflammation of all the coats of the wall, may or may not have cloudy fluid in the peritoneal cavity; (2) *acute with abscess*—perforation has occurred but the process has been walled off with formation of an abscess; (3) *acute with spreading peritonitis*—perforation with thick pus in the peritoneal cavity with no localization. Spreading peritonitis is a better term than general or diffuse peritonitis for we do not explore the abdomen, hence do not know definitely how general the process is. Fibrinopurulent peritonitis is merely the later stages of the same process.

DIAGNOSIS

The diagnosis of appendicitis in children is not more difficult than in adults in spite of the usual inability to get a full and accurate history and the frequent inability of the patient to co-operate. The symptoms and signs are not vastly different but we have to depend more on the cardinal symptom of pain and the fundamental sign of localized tenderness.

Pain is the first and predominating symptom in the vast majority of cases. In fact Lord Moynihan stated that if pain was not the first symptom, appendicitis could be dismissed. Like most dogmatic generalizations, this is an error. We had one case in which

Chart 1. Age distribution of 660 cases as reported by Beekman, Woodall, and Caldwell.

there was at no time any evidence of pain. This was a 6 year old girl who had had symptoms, the first of which was vomiting, for 36 hours before admission. Bolling reports 3 cases in which there was no pain. In 169 of our cases pain was the first symptom noticed; in almost all cases it is at first generalized and may or may not become localized in the right lower quadrant. Frequently, it is referred to the region of the umbilicus even late in the disease. Table I shows the incidence of pain and vomiting in 5 large series.

Vomiting is the next most frequent symptom, being present in 192 of the 220 cases. It ushered in the attack in 24. It was absent even in some of the late cases with abscess or diffuse peritonitis. Vomiting was present in 86 per cent of Stone's cases and was the first symptom in 8 of 258, corresponding fairly closely to our experience.

Other symptoms are of more or less minor importance. Constipation is much more frequent than diarrhea. In fact diarrhea occurred in only 12 of our cases, in 2 of which it was the first symptom. Anorexia and nausea are hard to evaluate in children, but are usually present. Unusual symptoms, such as headache, convulsions, or dysuria, may be the first to be noticed by the parents. One child first complained of pain on voiding, and red blood cells and leucocytes were found in the urine. At operation an acutely inflamed retrocecal appendix touching the ureter was found.

Fever is probably always present in the early stages of the disease but frequently on admission to the hospital the temperature is normal or subnormal. This may be true in any stage of the disease. The temperature averages higher in the later stages but in the individual case it is of no help in determining whether general peritonitis, abscess, or localized peritonitis is present, since the extreme range of temperature is about the same in all groups. In our acute cases the average temperature on admission was 100.4 degrees F. with a range from 98 to 104 degrees. In the cases with abscess the average was 101.4 degrees F. with a range from 99 to 105 degrees. In cases with spreading peritonitis the average was 101.9 degrees F. with extremes of 99 to 105 degrees. Beekman reports almost identical figures.

The degree of leucocytosis is of little diagnostic or prognostic value. Ochsner long ago said that the white count was of value chiefly in following the postoperative course. Beekman says that "from a diagnostic or prognostic standpoint no deductions could be drawn" from the white blood count. Table II shows the white count and the percentage of polymorphonuclear neutrophils in the different groups. We have not used the sedimentation rate in enough cases to draw conclusions but doubt that it is of great value in children.

The most important physical sign, as in adults, is localized tenderness. Although in some children it is difficult to interpret it is safe to say that it is invariably present. Rebound tenderness, psoas sign, skin hyperesthesia are refinements which are occasionally useful, but we have to depend on the one all-important sign—localized tenderness—and be patient and careful in the examination until we can get the child to co-operate, allowing a fair evaluation of the amount of tenderness. Spasm and rigidity are late signs and merely corroborate the tenderness. Rectal examination is more frequently helpful than in adults because in the small pelvis the examining finger reaches relatively higher.

TABLE II.

	Acute	Abscess	Acute with peritonitis
Temperature			
Average	100.4	101.4	101.9
Maximum	104	105.2	105
Minimum	98	99	99
White blood cells			
Average	15,000	21,200	18,700
Maximum	33,000	37,000	44,000
Minimum	5,000	9,000	4,000
Polymorphonuclear neutrophils, %			
Average	82	83	82
Maximum	98	92	97
Minimum	29	71	19

DIFFERENTIAL DIAGNOSIS

We made numerous diagnostic mistakes in the period covered by this report and have taken out approximately forty normal appendices. This is due to our policy of exploring whenever there is a reasonable chance that we are dealing with an early acute appendicitis.

The most frequent condition which we mistake for acute appendicitis is an acute mesenteric lymphadenitis following an acute upper respiratory infection. The infective organisms presumably are swallowed, pass through the intact intestinal mucosa, and cause inflammation of the mesenteric nodes which are most numerous about the ileocecal region. The signs and symptoms may exactly simulate those of acute appendicitis and I know of no way to differentiate between the two, with certainty, in all cases.

Food poisoning may simulate acute appendicitis. The products of many organisms, including certain strains of staphylococci and streptococci, have been found to cause intestinal upsets. These attacks are usually ushered in by violent vomiting and diarrhea with abdominal pain. Localized tenderness is rare, but may be present. We are suspicious of any case in which diarrhea is an outstanding symptom, especially if it is the first symptom, since this occurred only twice in our series.

The early symptoms of pneumonia may be largely abdominal. The tenderness and pain are usually in the upper quadrants, however, and careful physical examination and fluoroscopy should prevent this mistake. Primary peritonitis is uncommon, but in some cases is almost impossible to differentiate. On rare occasions a diagnostic puncture is justified.

TREATMENT

The chief point of contention in the treatment of appendicitis is immediate or delayed

operation in the cases complicated by peritonitis. During recent years many surgeons have advocated the Ochsner method of treatment—starvation, morphine, and rest until localization has occurred. Some have even gone so far as to set a definite time limit—if they cannot operate in the first 36 or 48 hours, they routinely adopt the so called conservative treatment. This is not logical, for time is only one of the important factors in the disease. Some appendices are gangrenous, and there is a spreading peritonitis within 3 hours of the onset of symptoms; others will rupture a week or 10 days after the onset. Nor is it possible to tell from the history and physical findings whether peritonitis is present or not. Frequently in children with a rigid abdomen we find at operation a fairly early appendicitis with cloudy fluid or thin pus in the peritoneal cavity. On culture this fluid is sterile or shows a pure culture of Bacillus coli. If the appendix is removed at this stage we may confidently expect a rapid and uncomplicated recovery. On the other hand, if the appendix is not removed the walls disintegrate and a mixed infection with streptococcus, staphylococcus, and other organisms develops, and in these mixed infections the mortality, as Meleney has shown, is very high under any treatment.

It is true that I have had little experience with the Ochsner treatment, but from the experience of other fair observers I am not encouraged to adopt it. Woodall, in a total of 295 cases in children, had 22 deaths. Thirteen of these had received the Ochsner treatment. Seven died before they were thought suitable for operation and 6 died after drainage of abscesses. His conclusion is that "young children do not stand the starvation or Ochsner treatment nearly as well as adults." I believe that even in the late cases in which we are certain that we are dealing with a general peritonitis the appendix should be taken out as soon as possible. This does not mean immediately on admission but as soon as the child can be gotten in the best possible condition for operation, as soon as dehydration and acidosis have been corrected by infusion, and, in those needing it, a blood transfusion has been given. Morphine is given in the meantime to give the child much needed rest.

A good example of how we believe the late cases of peritonitis should be treated is T. F., No. 349,252. This was a 9 year old negro girl who was admitted 6 days after the onset of symptoms. She was desperately ill, dehydrated, with sunken eyes, temperature 104.6 degrees F.; pulse, 160, thready and weak; there was frequent fecal vomiting. The abdomen was distended and board-like throughout. She was given morphine, and an infusion of 300 cubic centimeters of 5 per cent glucose in normal saline and a continuous drip venoclysis at the rate of 200 cubic centimeters per hour, and a direct transfusion of 250 cubic centimeters. At the end of 8 hours she was in much better shape and the appendix was removed through an intermuscular incision. She left the operating room with a pulse slower and stronger than when she entered it. The peritoneal cavity was full of pus, and the appendix with fecalith had ruptured. She developed a subhepatic abscess which was drained through a separate intermuscular incision. Otherwise she made an uneventful recovery. These children stand operation well but they do not stand a gangrenous appendix left to reach its final stages of fibrinopurulent peritonitis and multiple abscesses.

Frequently a patient comes in with a long history and a mass in the right lower quadrant; the question arises whether to operate immediately or wait for further localization of the process. We always operate immediately and in fully 50 per cent of the cases we find an unruptured, acutely inflamed appendix buried in a matted mass of omentum and small intestine. It is certainly better to have the appendix cleanly out than to wait for abscess formation with the possibility that the local defenses will not be adequate and a general peritonitis ensue, or a mechanical ileus, or a suppurative thrombophlebitis. We wholeheartedly agree with Urban Maes who says, "Undoubtedly immediate operation is the wiser plan in children just as it is at any age."

Only 10 times in these 220 cases was a right rectus incision made. In all others the McBurney incision was used. In these 10 cases the rectus incision was made because an abscess had pointed near the midline, or be-

cause there was great doubt as to the diagnosis. There were 2 deaths in the 10 cases, a mortality of 20 per cent, compared to 4 deaths in the 210 cases with intermuscular incisions, or 1.9 per cent. This is an unfair comparison and means little, but Colt compared the mortality of the intermuscular incision to that of the paracentral in two large series done by the same surgeons. The mortality in the 403 cases in which the intermuscular incision was used was 2.99 per cent while in the 696 cases done through a paracentral incision the mortality was 6.47 per cent. Mont Reid reports that at the Cincinnati General Hospital the adoption of the McBurney incision cut the mortality approximately in half. This seems to be conclusive statistical proof of what we are absolutely certain to be true, that the intermuscular incision is the one of choice. Not only is the mortality less but the incidence of hernia is markedly less, the hospital stay is shorter, and the convalescence smoother.

There is no question that better exposure is obtained by a long rectus incision but we have never failed to be able to remove an appendix through the McBurney incision. In this connection we would make two points regarding operation through an intermuscular incision in children. The incision should be made higher than is ordinarily done in adults; it should be entirely above the line between the umbilicus and the anterior superior spine. The rotation of the colon is more apt to be incomplete in children, hence the appendix is higher; also, the difficult appendices to remove are the retrocecal ones in which the tip is fixed at the level of the hepatic flexure. The low or pelvic appendices are attached to mobile ceca which can be lifted out and the appendix removed with ease through any incision. If the tip of the appendix is not easily delivered, the base should be divided and the cecum returned to the abdominal cavity. The appendix is then freed from base to tip. It is surprising how frequently this maneuver makes an otherwise difficult job easy and simple.

As to whether to invert the stump of the appendix or not we feel that the simplest surgery is usually the best surgery; so we simply ligate and carbolize the stump. The purse-string suture with inversion and covering the site with omentum is not only a waste of time and a useless refinement but is surgically unsound.

There has been a tendency to less and less use of drains in recent years and for good reasons. We drain only in those cases in which there is an abscess or other local focus. If there is marked induration or necrosis of the cecal wall, a fecal fistula is apt to form and a drain should be left in. Only soft cigarette drains are used. Diffuse or localized peritonitis is not in itself an indication for drainage and convalescence is faster if the abdomen is closed and the peritoneal infection left to nature's defenses. In doubtful cases, however, in which there is very thick pus or much fibrin deposited about the region of the cecum, it is safer to insert a soft drain as it does little or no harm and may prevent the formation of an abscess. In drained cases the peritoneum should be sutured and the remainder of the abdominal wall packed lightly with iodoform gauze. Suturing muscle and fascia in the presence of gross infection merely spreads the infection, causes sloughing of the fascia, and increases the chances of a mixed or anaerobic infection. I have never seen a serious infection of the abdominal wall develop in a wound that was packed open. The incidence of ventral hernia following appendicectomy with drainage was found by Pool to be 16 per cent if the wound was sutured and 7 per cent if it was left open. Bancroft and Beekman have also found that suture of the peritoneum only is preferable to closure of the fascia and muscles as well in the drained cases.

In the cases with spreading peritonitis it is not unusual for secondary abscesses to form after the removal of the appendix. These usually develop in the pelvis and occur whether drainage is or is not used. We believe that watchful waiting is the best policy in caring for these, as more than half will be absorbed without operative intervention. Some will rupture spontaneously into the rectum. The others should be drained but not until well localized and walled off. If one waits until the mass is well defined and "points," it is usually possible to drain it through a small wound and without soiling the free peritoneal cavity. There were 15 such secondary ab-

TABLE III.—MORTALITY

Author	Acute		Acute with abscess		Acute with spreading peritonitis		Total	
	Cases	Mortality	Cases	Mortality	Cases	Mortality	Cases	Mortality
Caldwell	103	.97	50	2.0	67	6.0	220	2.7
Woodall							295	7.45
Tasche	38	2.6	33	9.0	11	27.3	82	8.5
Keves	99	2.02	122	0.0	42	38.1	263	11.0
McLanahan	125	0	28	0	26	26.9	179	3.9
Kaiser	134	.75	46	6.5	35	23.0	215	5.6
Beekman	48	0	53	5.7	44	18.2	145	7.6
Stone	142	0	72	6.9	44	34.0	258	
Bolling							123	8.1
Maes	127	0	84	8.3	39	30.8	250	7.6
Finney	115	1.7	49	2.0	29	31.0	193	6.2
Haggard	1650	.7	379	Adults 5.0	186	24.7		
Finney		1.4		4.5		22.0	4000	

scesses in this series, in only 3 of which was operative intervention necessary. The others were absorbed or ruptured spontaneously.

Nearly all of these children are suffering from more or less severe acidosis and are dehydrated when they enter the hospital and the parenteral administration of glucose and saline should be used freely before and after operation. We have found the use of pitressin, as advocated by Potter, useful in preventing and combating postoperative distention. In children under 7 we use one-half cubic centimeter or 10 u. every 4 hours beginning before operation and continuing until the danger of ileus is past. In children over 7 the full adult dose of 20 u. is given.

MORTALITY

Table III shows our mortality and that of other series in children. It is usually stated that mortality in children is higher than in adults. Our figures show that this is not necessarily true. The recuperative power of the child is remarkable. It is true that the disease progresses faster than in the adult and that a larger percentage will enter the hospital with spreading peritonitis. Whether this is due to the small and undeveloped omentum, as is frequently stated, we have no way of knowing, but we rather believe it is just another instance that all vital processes proceed more rapidly in the growing body.

The greatest factor in the mortality, of course, is the duration of the disease before operation. In the early cases, when operation is done before rupture has occurred, the mortality should be, and is, negligible. In our acute cases the average duration of symptoms before patient entered the hospital was 1.3 days; in the peritonitis cases it was 2.7 days; and in the cases with abscess it was 4.0 days.

A brief analysis of our deaths follows:

S. N., No. 328,421, female, aged 2 years; duration of symptoms, 5 days. Temperature was 103 degrees, F.; 9,000 white blood cells per cubic millimeter with 62 per cent polymorphonuclear neutrophils. Exploration was done through a right rectus incision; the peritoneal cavity was found to be filled with thick pus. The appendix was not removed. Cigarette drains were placed in the pelvis and region of the appendix. Death occurred 24 hours after operation from peritonitis and sepsis. No autopsy.

This child had no pre-operative treatment. In view of the high mortality at this age she should have had a transfusion and infusion or venoclysis before operation. Appendicitis at this stage is not an immediate operative emergency and 6 to 12 hours should be devoted to getting the patient into the best possible condition for operation. It was a great mistake to use a right rectus incision as there is no comparison between the shock to the patient in exploring through a McBurney, rather than a rectus, incision.

S. W., No. 222,854, female, aged 20 months; duration of symptoms, 30 hours. Temperature was 101.6 degrees F.; white blood cells, 4,000; polymorphonuclears, 19 per cent. The abdomen was rigid throughout. Patient was operated upon immediately, without pre-operative treatment. An acutely inflamed appendix with a fecalith and spreading peritonitis was found. Patient died on the operating table; death was called an "anesthetic" one.

The remarks on the previous case apply doubly strongly here. A baby under 2 years of age with leucopenia, peritonitis, and dehydration was subjected to exploration through a right rectus incision without pre-operative treatment. This was a surgical crime rather than an anesthetic death.

R. W., No. 231,721, male, aged 3 years 9 months; duration of symptoms, 5 days. Temperature was 105 degrees F.; white blood cells, 12,000; with 87 per cent polymorphonuclears. No pre-operative treatment was given. The McBurney incision was used. Acute appendicitis with spreading peritonitis was found. Patient died 10 hours after operation. Again no attempt was made to get this child into condition for operation. Operation was a mistake and hastened death.

R. H., No. 187,623, male, 9 years of age; duration of symptoms, 18 hours. Temperature was 101.4 degrees F.; white blood cells, 4,600 with 88 per cent polymorphonuclears. Patient was in good condition on admission to hospital and an acutely inflamed appendix with fecalith was removed through a McBurney incision. After operation he ran a septic temperature; liver and spleen became enlarged; and he developed jaundice. Death occurred on the eleventh day, presumably from multiple liver abscesses. No autopsy.

Liver abscess following septic portal thrombophlebitis is the gravest complication of appendicitis. Fortunately it is rare. Except for gentle handling of tissues and avoidance of mass ligature of the mesoappendix we have no suggestions as to its prevention.

F. S., No. 222,802, female, aged 3 years; duration of symptoms, one month. Temperature was 99 degrees F.; white blood cells, 9,000. Large well localized pelvic abscess was found at operation, it was drained after adequate pre-operative treatment, and the appendix was not removed. Patient died suddenly 4 hours after operation. The cause of death was unknown but probably was a pulmonary embolus.

H. R., No. 317,605, male, aged 14 months; duration of symptoms, 4 days. White blood cells, 19,000 with 63 per cent polymorphonuclears. Clysis of glucose solution was given before operation. The McBurney incision was used. A ruptured appendix with spreading peritonitis was found. Patient vomited during operation and aspirated part of the vomitus. Direct transfusion and continuous drip venoclysis were administered after operation. Patient died 36 hours after operation from pneumonia.

Of our 6 deaths 3 were apparently unavoidable. In the other 3, grave surgical mistakes were made which were probably large factors in the fatal outcomes. In view of our responsibility for these deaths we are glad to be able to report a mortality appreciably lower than any similar series so far reported. One important factor in obtaining this low mortality was the close co-operation between the pediatricians and the surgeons. The care before and after operation was under the constant joint supervision of the medical and surgical staffs; a sound principle in all surgery but especially true of the surgery of childhood.

Of the 12 infants under 2 years of age 3 died, a mortality of 25 per cent. Although this is lower than the 50 per cent mortality reported by Abt, it is still unreasonably high and we believe can be reduced by proper pre-operative care. Dehydration and acidosis must be corrected before operation and it is possible that a blood transfusion should be a routine pre-operative procedure; certainly one should be prepared to give a transfusion at, or immediately after, operation. The same is true of patients at any age who have a leucopenia. We have found this to be a very grave prognostic sign and believe that all should have the benefit of a transfusion before and, if necessary, after operation.

While we are not satisfied with our mortality rate, it does give us confidence in our method of treatment and makes us believe that the principles are sound. We have no intention of dropping tried methods and adopting the delayed or Ochsner treatment. We are confident that our mortality would have been much higher if we had treated our late cases by that method.

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THE PERSISTENCE OF GONOCOCCAL INFECTION IN THE ADNEXA

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GONORRHEAL salpingitis pursues a variable course. In some cases recovery is complete, in others the disease becomes chronic, although acute exacerbations may be frequent. The cause of the variations observed clinically has given rise to much speculation and to some experimental work on the duration of gonorrheal infection in the fallopian tube. The literature, previous to 1921, leads one to believe that the gonococcus is to be demonstrated in the inflamed fallopian tubes and ovaries less often than one would expect from the clinical phenomena presented. Menge, in 1897, found the micro-organisms present in 22 of 106 cases of purulent salpingitis, or in 21.7 per cent. Hyde found them in 18.9 per cent of a series of 2,973 collected cases. Andrews reported positive growths in 22 per cent of 634 cases studied. These figures are reported from Crossen because the original articles could not be found. In 1921, Curtis undertook a further study of this problem, using inflamed fallopian tubes and ovaries which had been ground. He reported that in 192 cases there were 19 positive cultures of gonococci, or in 9.8 per cent. Of the 192 cases gonococci were not demonstrated in any case that did not at the same time reveal evidence of recent inflammation. He felt that the micro-organisms are rapidly killed, and that they are rarely recoverable in cultures later than 2 weeks after the disappearance of fever and leucocytosis. Since Curtis' work, nothing has been added. It is apparently the consensus that there is a bacteriolytic process which takes place in the actively inflamed fallopian tube that disposes of gonococci. However, in 1925 Wagner stated that in his opinion "the repeated flareups which are typical of gonorrheal salpingitis suggest that the organisms do not entirely disappear from the pyosalpinx even though they cannot be demonstrated in culture." This seems to be the only dissenting opinion.

The present study was undertaken to determine, if possible, whenever the gonococcus is persistent in cases that are clinically and pathologically recognized as chronic salpingitis. The results obtained are at variance with the older observations and for this reason warrant publication.

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TABLE I.—PRE-OPERATIVE TEMPERATURE COURSE IN HOSPITAL—24 CASES

Name	Number of febrile weeks (over 99°)	Number of afebrile weeks (below 99°)	Culture	Gonococcus complement fixation
A.S.	2	1	+	Not Done
E.D.	7	1	O	Not Done
S.C.		3	+	+
S.H.		3	O	+
E.S.	4	2	+	D
B.J.	1	2	+	+
M.D.		3	+	+
F.H.		1	O	D
A.Mc.	7	0	+	O
C.D.		2	O	+
M.J.		2	+	+
W.G.	1	3	O	+
L.S.		4	+	D
L.O.	4	4	+	Not done
R.H.		2	O	+
M.B.	2	0	+	O
B.G.		6	+	+
F.W.		2	O	+
L.P.		2	+	O
G.T.	2	5	+	Not done
A.B.	2	2	+	+
O.B.		2	+	
A.P.		2	+	+
D.P.	3	3	O	O

Material. Inflamed tubes and ovaries removed at operation from 24 consecutive patients (Table I) were used as material for this investigation. All of the patients, as may be seen in Table II, had been under observation for some time, and most of them had been afebrile for at least 2 weeks.

Method. Immediately after their removal at operation, cultures of the tubes and ovaries were taken. A sterile platinum loop was inserted through an incised opening in the tubal wall and passed toward the cornual end. Small pieces of exudate and tissue were obtained. In cases in which pus was encountered, cultures were made from it. The media used was 5 per cent horse blood-agar plate, hydrogen-ion concentration 7.5. Several plates from each tube were streaked. The plates were examined at the end of 24 or 48 hours. Smears were made from every suspicious colony and stained by the method of Gram. When gonococci were found by smear the plate colonies were recultured. In a few instances the initial colony showed degenerate forms of microorganisms (Fig. 1). On subculture these microorganisms assumed the usual morphological characteristics of the gonococcus (Fig. 2). Gonococcus complement fixation tests were performed in 20 of the 24 cases.

Results. Among the 24 cases studied there were 16 positive cultures of gonococci, or in 66.6 per cent. Positive cultures were obtained only from pieces of tissue and exudate. Cultures from pus were negative for gonococci.

Table II summarizes the 24 cases studied. The details are tabulated to show the results of the examination of cervical and urethral spreads, the duration of the salpingitis according to the history, the results of cultures of the tubes and of gonococcus complement fixation tests, and the naked-eye pathological changes observed at operation. Special interest was taken in the history in order to estimate as closely as possible, the duration of the salpingitis. The estimated duration ranged from 1 month to 10 years, the average being 18 months. All spreads were taken on admission and were seldom repeated, so that too much value cannot be placed on a negative report. Only one positive cervical spread is recorded among the 24 cases.

In 20 of the 24 cases, specimens of blood were sent to the New York City Board of Health Laboratories for gonococcus complement fixation tests. There is no apparent uniformity in the results of these tests and those of tubal cultures. Of 12 cases showing positive complement fixations, cultures were positive in 7 and negative in 5. Of 4 cases in which the complement fixation tests were negative, cultures were positive in 3. In 3 cases in which complement fixation tests were reported as

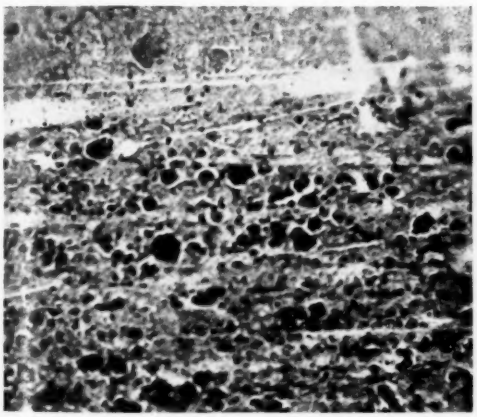

Fig. 1. Smear stained by Gram Weigert method. Taken from colony showing degenerate forms of gonococci. Note expanded irregular forms.

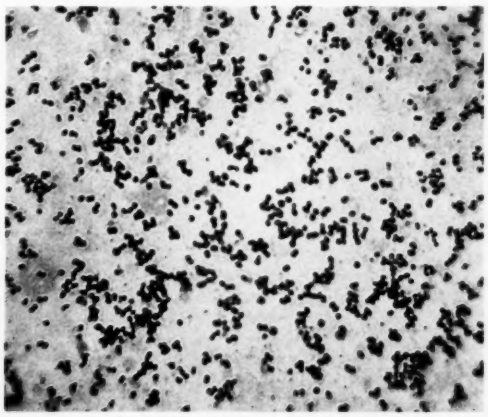

Fig. 2. Smear stained by Gram Weigert method. Taken from colony obtained by subculture showing return to characteristic appearance of gonococcus.

TABLE II.—SUMMARY OF CASES FROM WHICH CULTURES WERE OBTAINED

Name	Cervical spread	Urethral spread	Culture from tube	Duration of salpingitis	Gonococcus fixation	Naked-eye pathological changes
A.S.	Not done	Not done	Pos.	*About 3 months* Pain and discharge	Not done	Abscess left ovary. Right hydrosalpinx Left pyosalpinx
E.D.	Neg.	Doubtful	Neg.	*2 months* Vaginal bleeding and lower abdominal pain	Not done	Tubo-ovarian abscess
S.C.	Neg.	Neg.	Pos.	*1 year* Pain with periods	Positive	Bilateral pyosalpinx
S.H.	Not done	Not done	Neg.	*2.5 months* Vaginal bleeding and lower abdominal pain	Positive	Bilateral pyosalpinx and ovarian abscess
E.S.	Neg.	Doubtful	Pos.	*2 months* Left lower quadrant pain Clots with periods	Doubtful	Tubo-ovarian abscess
B.J.	Neg.	Neg.	Pos.	*7 months* Pain with prolongation of periods	Positive	Bilateral subacute follicular salpingitis; normal ovary; peritoneal adhesions
M.D.	Neg.	Neg.	Pos.	*4 years* Left lower quadrant pain	Positive	Right pyosalpinx
F.H.	Not done	Not done	Neg.	*6 months* Pain and swelling in left lower abdomen	Doubtful	Tubo-ovarian abscess
A.Mc.	Neg.	Neg.	Pos.	*1 year and 2 months* Previous tubo-ovarian abscess ruptured, peritonitis	Negative	Bilateral tubo-ovarian abscess
C.D.	Neg.	Neg.	Neg.	*1 month* Metrorrhagia with pain in lower abdomen	Positive	Slight subacute salpingitis with peritoneal adhesions. Follicular cysts of ovary
M.J.	Neg.	Neg.	Pos.	*6 months* Lower abdominal pain with metrorrhagia	Positive	Tubo-ovarian abscess; fibromyoma uteri
W.G.	Neg.	Doubtful	Neg.	*3 years* Lower abdominal pain, menorrhagia, Leucorrhea	Positive	Bilateral subacute follicular salpingitis. Normal ovary
L.S.	Neg.	Neg.	Pos.	*1.5 months* Lower quadrant pain with discharge	Doubtful	Subacute follicular salpingitis
L.O.	Not done	Not done	Pos.	*1 year* Postmenstrual pain. Menorrhagia	Hemo.	Tubo-ovarian abscess
R.H.	Neg.	Neg.	Neg.	*2 months*. Pain in epigastrium and in lower abdomen. No discharge	Positive	Subacute follicular salpingitis. Peritoneal adhesions
M.B.	Not done	Not done	Pos.	*10 years* Left lower quadrant pain. Irregular periods.	Negative	Right pyosalpinx Endometrial polyp. Peritoneal adhesions
B.G.	Neg.	Neg.	Pos.	*3 months* Left lower quadrant pain Passage of clots from vagina.	Positive	Left tubo-ovarian abscess
F.W.	Neg.	Neg.	Neg.	*6 months* Periodic left lower quadrant pain	Positive	Chronic salpingitis Tubo-ovarian abscess
L.P.	Not done	Not done	Pos.	*3 years* Turpentine and mineral oil injection of tubo-ovarian abscess—1933	Negative	Fibromyoma uteri Old left tubo-ovarian abscess
G.T.	Neg.	Doubtful	Pos.	*5 months* Irregular periods		Left tubo-ovarian abscess (old) Chronic salpingitis
A.B.	Pos.	Neg.	Pos.	*1 year* Lower abdominal pain with metrorrhagia	Positive	Chronic salpingitis with pyosalpinx
O.B.	Not done	Not done	Pos.	*2 years* Lower abdominal pain		*Subacute salpingitis* with tubo-ovarian abscess left
A.P.	Neg.	Neg.	Pos.	*6 months* Right lower quadrant pain	Positive	Right tubo-ovarian abscess Chronic salpingitis
D.H.	Neg.	Neg.	Neg.	*2 years* Salpingitis with peritonitis *1935* Left lower quadrant pain	Negative	Left tubo-ovarian abscess Chronic salpingitis

doubtful, cultures were positive in 2. This serves to show that the gonococcus fixation test was not a reliable index of infection in the patients under consideration.

Pathology. The naked-eye pathological changes are summarized in Table II.

Microscopic sections were studied in all cases. On the basis of the type of exudate and the degree of fibrosis present, one may formulate the following grades of salpingitis. (1) Acute salpingitis, characterized by a rich exudate of polymorphonuclear leucocytes in the stroma and lumen, and injection of small blood vessels with few or no structural alterations in the tube. (2) Subacute salpingitis, the exudate consisting largely of plasma cells, lymphocytes, and eosinophils with marked structural changes in the walls of the tube. (3) Acute exacerbation of chronic salpingitis in which reaction similar to that of Type I is present together with marked structural changes. (4) Chronic or healed salpingitis showing little if any active inflammatory reaction, and marked structural changes in the walls of the tube.

Among the specimens removed at operation, no example of acute exudative salpingitis was found (Type I). Nineteen were regarded as subacute salpingitis and from them 13 positive and 6 negative cultures were obtained (Type II). Two specimens were classified as acute exacerbations of chronic salpingitis (Type III) and both gave positive cultures. Three specimens were classified as chronic or healed lesions (Type IV) and of these one gave a positive culture.

The microscopic diagnoses of the changes in the tubes and their relationship to the gonococcus as the causative factor, are summarized in Table III.

The following cases are of special interest and are reported in detail:

CASE 1. Mrs. L.P., 29 years of age, colored. In 1933 the patient was admitted to the Gynecological Service at Bellevue Hospital and operated upon for a left tubo-ovarian abscess. In an attempt at conservative surgery, the left tubo-ovarian abscess was injected with turpentine and mineral oil. Postoperative diathermy was given. The patient did well until 1936, when she developed menorrhagia and pain in the left lower abdomen. She was readmitted in May, 1937, for this complaint, and was again operated upon, that is to say, 4 years after the turpentine injection. At operation an intraligamentous fibromyoma was found and the left tube (previously injected with turpentine) was found to be about three times the normal size, thickened, clubbed, and closed; it was covered with adhesions. Culture from the tube was positive for gonococci. The gonococcus complement fixation test and cervical spreads were negative.

TABLE III.—THE RELATION OF CULTURAL FINDINGS TO THE HISTOLOGICAL PICTURE IN THE INFLAMED TUBE

	Total	Positive culture	Negative
Type II Subacute salpingitis	19	13	6
Type III Subacute salpingitis with superimposed acute inflammatory reaction	2	2	0
Type IV Chronic (healed) salpingitis	3	1	2
	24	16	8

CASE 2. Mrs. M.B., Spanish, 48 years of age. The patient's chief complaint was that of violent pelvic pain which had been present for 10 years. It was described as of a "twisting" nature, occurring in the left lower quadrant, occasionally severe enough to cause her to faint. During the first episode of this sort she was in Mexico, and a curettage was done. Since that time there have been recurrences of pain similar in character and distribution. Her husband died 10 years ago, and she claims to have had no intercourse since then. She has been sterile for 20 years On physical examination she was believed to have a cystic mass in the right adnexa, the nature of which was questionable; the pre-operative diagnosis was ovarian cyst. She had no fever while under observation for 2½ weeks. At operation, on April 13, 1937, a right sided hydrosalpinx was found, forming a mass 4 inches in diameter, adherent in the cul-de-sac and bound to the side of the pelvis by dense adhesions. Culture from the hydrosalpinx was positive for gonococci, and the colony was recultured in pure growth. The gonococcus complement fixation test and spreads were negative.

CASE 3. Miss A.B. The patient was found on admission to have a positive cervical spread. Her chief complaint of left sided pain in the lower abdomen was of a year's duration. Examination revealed a tender, left sided adnexal mass, 5 by 5 by 6 centimeters in diameter. The temperature ranged between 99 and 100 degrees for the first week. She was given a hyperpyrexia treatment on two occasions at a temperature of 107 degrees for 8 hours. In addition, she received eight Elliott treatments alone. Cervical spreads, repeated after hot-box treatment, were negative for gonococci. She was

afebrile 2 weeks prior to operation. At operation May 13, 1937, chronic left sided salpingitis was found, together with an abscess of the corresponding ovary. The abscess was 5 centimeters in diameter and the adjacent tube was clubbed, firm, closed, and thickened. Cultures from the ovary and tube were positive for gonococci, and the gonococcus fixation test was positive.

SUMMARY

Twenty-four patients suffering from salpingitis were investigated bacteriologically. Of this number 66.6 per cent were found to harbor gonococci in spite of the fact that none of them was in the acute stage of the disease. In 1 case it seems likely that the most recent infection took place at least 10 years ago. In another, the tube had been injected with turpentine. In a third, fever therapy had apparently cured the local cervical infection. Gonococcus complement fixation tests were found to be frequently at variance with the results of culture. While the recovered gonococci were occasionally degenerate in form, they rapidly assumed the usual characteristics on subculture.

CONCLUSIONS

1. Contrary to previous reports, the fallopian tubes may remain as active foci of gonococcal infection for long periods of time.
2. Many cases regarded as acute exacerbations of chronic salpingitis may be due to recrudescences of residual infections rather than to reinfections.
3. Gonococci may survive in the tube in the presence of turpentine and mineral oil.
4. Gonococci may survive in the tube despite apparent cure of local cervical infection by hyperpyrexia.

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EXPERIMENTAL METHODS OF LUNG COLLAPSE

Fascial Transplantation and Bronchial Ligation

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THE lung is constantly distended by two forces which work simultaneously on both sides of its alveolar membrane. One is external, the negative pleural pressure which exerts an outward pull; the other is internal, the air under atmospheric pressure which distends the alveolar membrane.

If the lung is freed from the negative pleural pressure it will retract itself to a relaxed state. If the bronchi are obstructed the lung will no longer remain normally distended, and after absorption of the contained air, will adopt its initial volume, a condition of atelectasis. The former is the explanation of the mechanics of a pneumothorax, and the latter is the explanation of what we observed in bronchial ligation. Pneumothoracic collapse therapy in pulmonary tuberculosis is successful in a high percentage of cases in which adhesions do not prevent a satisfactory collapse of the cavity. All too frequently, however, a broad band or irregular adhesion between the lung and chest wall, too large to be safely divided, prevents collapse of the cavity and a so-called "hanging cavity" results. Thoracoplastic collapse therapy, when indicated, is usually successful in producing a satisfactory collapse of pulmonary cavities. Occasionally, however, circular, fairly thin walled cavities refuse to collapse completely but simply move over to the mediastinum (behind the sternum) with collapse of the chest wall. Eloesser, in his exhaustive study of this type of lesion, concluded that as yet there is no satisfactory operation for uniformly meeting this problem.

Nissen and Fick (3) tried the envelopment of pulmonary lobes of healthy dogs with silk in an attempt to produce pleural adhesions which would facilitate lobectomy in cases of bronchiectasis. Wolfe and Van Allen compressed lobes of normal animals with a rubber sac hoping to obtain pulmonary collapse by the formation of a thick capsule of fibrous tissue in the visceral pleura. In both of these sets of experiments there was a considerable diminution in the volume of the compressed lobe which was transformed into a retractile hilar stump. On the other hand the pleural reaction due to the foreign material was the cause of death in several of the animals of the latter workers.

From the results noted we felt that the procedure might be better tolerated by substituting organic transplants for the inorganic materials heretofore employed. Consequently, it was planned to attempt pulmonary collapse with transplants of fascia.

EXPERIMENT

Five normal dogs were used. The chest was opened, the selected lobe was brought out, and the fascial transplant sewed around it. In 2 cases the right middle lobe was selected and in the 3 remaining dogs, the left upper lobe was collapsed. The chest was closed. The dogs were killed after 3 months and autopsies were performed.

Technical details. After a preliminary injection of morphine each dog was prepared for a sterile operation. The fascial transplant was first taken from the leg. Subsequently, in order to have enough material, it was taken from the abdominal wall (rectus sheath). Under ether-intratracheal anesthesia and positive pressure, the pleural cavity was opened by an 8 centimeter incision in the fifth intercostal space. The selected lobe was brought out and its volume reduced by spontaneous relaxation by decreasing the positive pressure. The fascial transplant was then sewed snugly around the lobe so as to cover all its surface beginning at the hilus and following toward the periphery with interrupted sutures. Care was necessary not to constrict the ves-

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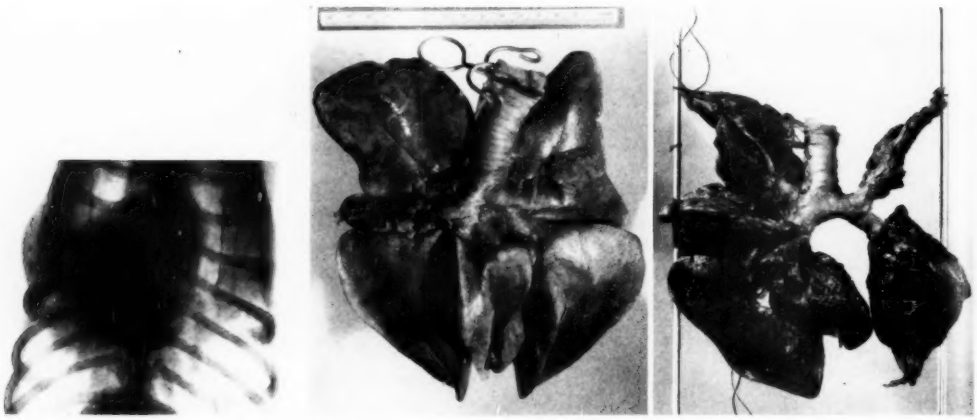

a b c

Fig. 1. a, Dog 738. Roentgenogram of chest taken 4 weeks following fascial collapse of the right middle lobe. b, Photograph of specimen of Dog 790 sacrificed 3 weeks following fascial collapse of right middle lobe. c, Photograph of specimen of Dog 956 sacrificed 3 months following fascial collapse of the left upper lobe.

sels at the hilus since two of the first animals died of gangrene of the lung. The intratracheal pressure was increased, the other lobes were inflated to exclude the pneumothorax, and the chest wound was closed.

The operation was always very well tolerated; there was no operative mortality. The postoperative course was closely observed. No dyspnea or cyanosis developed. Frequent radioscopic and radiographic examinations were made (Fig. 1, a).

The first two dogs died; the 3 remaining ones were sacrificed and examined by autopsy, 1 and 3 months after the operation. Gross and microscopic examinations of the lungs were made, particularly of the collapsed lobe.

Results. Two of the 5 normal dogs died of gangrene of the lung due to compression of the blood vessel 2 or 3 days after operation. The other dogs made an uneventful recovery. Two days after operation they became active and began to behave normally. After 3 months a roentgenographic examination showed the side of operation to be somewhat flattened, the ribs and diaphragm on the same side limited in motion, the heart drawn a little to the collapsed side, and the postoperative lobe atelectatic.

Gross postmortem findings. At autopsy the lobe operated upon was found to be attached to the surrounding parts by dense adhesions, but no exudate was present. One month after the operation the collapsed lobe was shrunken to one-fourth and 3 months after the operation to one-seventh of its original size. The cut surface of the lobe had the dark purple brown color of atelectasis (brown, firm, and atelectatic). By the end of 3 months the lobe was less than half as large as it was when relaxed by opening the chest. The other lobes were distended and occupied the space which was no longer occupied by the collapsed lobe, and it was probably on this account that the heart and diaphragm were saved from becoming extensively displaced, in compensation for the reduction of size of the treated lobe (Fig. 1, b). The fascial transplant was always found to be in a desirable position surrounding the collapsed lobe. On subsequent examinations the fascial envelop appeared decreased in size, thus causing a reduction in the size of the compressed lobe (Fig. 1, c). Microscopic findings revealed complete atelectasis of the collapsed lobe (Fig. 2, a and b).

Protocol 1 (Dog 738) August 13, 1936. Fascial transplant around the right middle lobe. The operation was performed under ether-intratracheal anesthesia following a pre-operative dose of morphine. A long incision was made in the right thigh and a large piece of fascia was obtained. The right chest

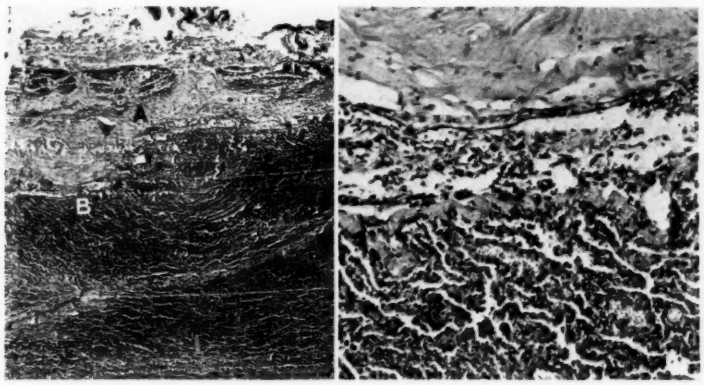

Fig. 2. a, left. L. P. Photomicrograph of specimen 3 weeks following fascial collapse. Note the fascial capsule, *A*, and the atelectatic lung tissue, *B*. b, high power at *B* (Fig. 2, a) showing atelectasis.

was opened through the fifth intercostal space, and the fascial transplant was sewed snugly about the middle lobe. The chest was closed in three layers with silk sutures. The incision in the leg was also closed.

August 14, 1936, the dog ate little and appeared somewhat weak. August 16, 1936, the dog was much better and ate normally. August 20, 1936, the dog appeared sick due to the infection of the leg wound. Care was taken of the wound. September 5, 1936, the dog appeared normal except for a little infection in the leg wound. September 12, 1936, fluoroscopy revealed no exudate; the shadow at the right of the heart was smaller than in the previous examination. September 15, 1936, roentgenograms were taken. The animal was electrocuted. Postmortem examination was made. No pleural exudate was found. The right middle lobe enveloped in the fascia was very much reduced in size and adherent to the lower lobe. Microscopic sections revealed atelectatic lung tissue.

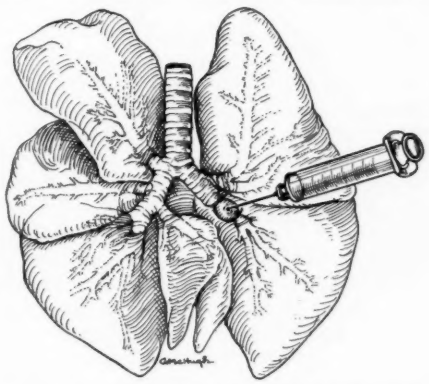

Fig. 3. a, Illustration demonstrating the method of injection of silver nitrate following double ligation of a bronchus.

Bronchial ligation. A second method of producing lung collapse that we wish to present is by bronchial ligation. As far back as 1850 Gairdner published a paper with the following subtitle "Collapse of the Lung Connected with Bronchial Obstruction." In 1879 Lichtheim showed that the air absorption occurring in bronchial obstruction was accomplished by the blood circulating in the alveoli; in fact if the branch of the pulmonary artery corresponding to the obstructed bronchus was ligated, atelectasis did not occur. In 1923 Nissen studied bronchial ligation and drew the conclusion that it would never have any practical application. In 1933 one of us reported

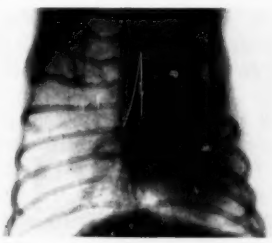

Fig. 3. b, Dog 147. Roentgenogram of chest 8 weeks following collapse of the left lung by bronchial ligation. Note collapse of lung and deviation.

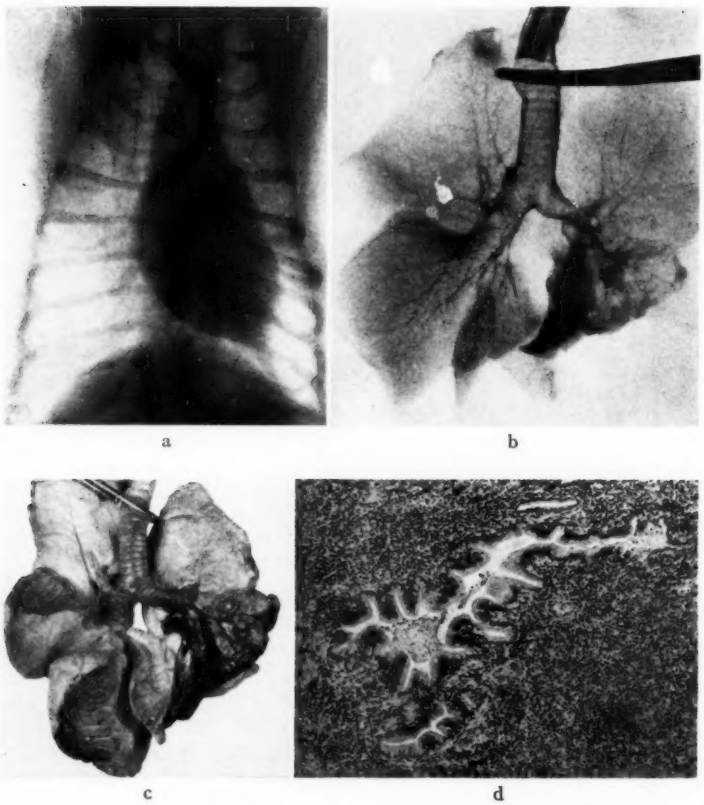

Fig. 4. a, Dog 590. Roentgenogram of chest 4 months following collapse of left lower lobe by bronchial ligation. b, Roentgenogram of specimen of Dog 590. Note collapse of left lower lobe of 4 months' duration. c, Photograph of specimen of Figure 4, b. d, Photomicrograph of collapsed left lower lobe. Note complete atelectasis.

a method of closing the bronchi from within by the silver nitrate technique (W.E.A., 1). This method so successful in the treatment of experimental lung tuberculosis has not yet reached the stage of clinical application in that disease. It seemed that the bronchial secretions washing out the silver nitrate were the cause of the incomplete bronchial occlusion in the human cases in which it was used. An attempt was made to obviate this by keeping the silver nitrate confined to the desired locations by means of the following method. The primary bronchus of one or two lobes was doubly ligated with linen and 1/20 to 1/10 cubic centimeter of a 10 to 35 per cent solution of silver nitrate was injected into the bronchus between the two ligatures just before or after the distal ligature was applied. In order to test the efficacy of this procedure before applying it to the treatment of tuberculous cavities of the lung, an attempt was made in healthy animals. It was hoped to obtain changes in the anatomy and physiology of this ligated lobe, i.e. production of atelectasis and interruption of its essential normal function, the gas exchange. Furthermore it is well known that if air is no longer present in the alveoli the functional circulation carried out by the pulmonary artery becomes unnecessary and the irrigation of the atelectatic lobe

is accomplished, chiefly by the nutritional artery (the bronchial artery). The ligated lobe is put at complete rest,—perhaps more complete than by any other known method of collapse, and in a state which is considered ideal for the healing of tuberculosis of the lung.

Technical details. Ether was administered by the intratracheal insufflation method at a pressure of from 20 to 35 millimeters of mercury. The chest was opened through an incision in the fifth intercostal space. The lung was reflected anteriorly and the primary or the stem bronchus was isolated from the surrounding tissues. A double ligature of linen was passed about the bronchus, care being taken to avoid including the bronchial artery and the bronchial nerves in the ligatures. The central ligature was tied, and before the distal ligature was approximated 1/20 to 1/10 of a cubic centimeter of a 10 to 35 per cent solution of silver nitrate was injected into the bronchus between the two ligatures (Fig. 3, a). After having lost an animal due to the *necrosing* action of 35 per cent silver nitrate upon the lung structure, the injection of the silver nitrate was postponed until after both ligatures had been tied. Thus the solution could not spread distally nor centrally to the ligature. In some cases the insufflation was interrupted for a few seconds to allow collapse of the lung, and after its collapse the ligature was firmly tied. The insufflation was again started, and the total occlusion of the bronchus tested by attempts to distend the lung. The chest was then closed with pericostal sutures, sometimes the other lung being strongly distended with air before the last suture was tied, and normal respiration re-established by removing the insufflation tube from the trachea. This operation required only a few minutes for its performance, and was carried out in each case without mishap. Even when the right or left primary bronchus was ligated the operation was well tolerated. It was interesting to observe that the acute occlusion of a completely normal functioning lung (i.e. one-half of the respiratory system) could be so well endured. This confirmed the recent clinical observation in pneumonectomy for carcinoma of the lung. At the moment of the ligation the heart beat became slower but the respiratory rate increased in frequency. The postoperative symptoms were observed. Frequent fluoroscopic and x-ray examinations were made and no exudate was demonstrable. Atelectasis developed and the mediastinum and diaphragm were displaced toward the collapsed lobes especially when the whole lung had been collapsed (Fig. 3, b). The displacement of these structures was much less if only one lobe had been obstructed (Fig. 4, a). Bronchoscopic examinations were made and bronchial occlusion verified in all but 3 cases. In 1 dog the ligature cut through the bronchial wall and was observed at bronchoscopy.

Results. Of the 12 dogs used, 4 died. In 3 the cause of death was independent of the bronchial ligation (1 died of opening of the chest 11 days after operation; 1 died of pneumonia of the opposite lung 4 days after operation; 1 died of a pre-existing infection of one of the two lobes ligated (the other lobe was atelectatic at postmortem, 9 days after operation); the fourth dog died 3 days after operation due to necrosing action of the silver nitrate (35 per cent) which spread into the lung parenchyma. Eight dogs survived. The immediate effects of the operation were not severe. The dogs were active and ate with a relish. In some animals, dyspnea was observed especially when a complete lung was occluded. Three of these reopened later, one of which had been ligated about the left primary bronchus. The others remained closed. (The bronchi remained closed in 3 of the 4 dogs which died from other causes.)

Autopsy findings. The space left by the collapse of the lobe was obliterated, various factors taking part: the remaining lobes became distended, the mediastinum was displaced toward the collapsed lung, and the diaphragm on that side became somewhat elevated. The lobe operated upon appeared shrunken to one-fifth to one-eighth of its normal size. It was bluish-red in color and of the consistency of liver (Fig. 4, b and c). The ligature was found intact in all but 1 case. On sectioning with a knife, the cut surface bled but was of increased density. Bronchi and bronchioles were present on the cut surface but other lung structures were obliterated. Microscopic examination revealed the alveoli completely void of air

or exudate. Thus ligation of a primary bronchus produced complete atelectasis of its corresponding pulmonary lobe. In the only animal in which the bronchus reopened, a picture of bronchiectasis was found. Probably the pre-existing infection was the cause of its reopening.

Protocol 2. Dog. No. 590. Under ether-intratracheal anesthesia and positive pressure, the left chest was opened through the fifth intercostal space. The pulmonary ligament was cut. The lung was reflected anteriorly. The left inferior bronchus was ligated after being carefully freed from the surrounding vessels. The bronchus was doubly ligated with silk and 0.2 cubic centimeter of a solution of 35 per cent silver nitrate was injected between the ligatures. The chest was closed.

Postoperative course. The day after the operation the animal was up and ate well. At the end of the week it appeared entirely well. May 16, 1937, fluoroscopic and radioscopic examinations were made and atelectasis of the left lower lobe was observed. The heart had been displaced to the left and the diaphragm was somewhat elevated.

June 11, 1937, bronchoscopy revealed the left lower bronchus closed. June 20, 1937, fluoroscopy revealed no exudate; left lower lobe, atelectatic. September 10, 1937, fluoroscopy and x-ray examinations of the chest were made. The animal was sacrificed by electrocution. At autopsy no fluid was present in the chest. The left lower lobe bronchus was occluded and the lobe was atelectatic. The rest of the lung was normal.

EVALUATION OF STUDY

Collapse of a lung lobe by means of a fascial transplant was accomplished more easily by allowing spontaneous relaxation of the lobe by a short interruption of intratracheal positive pressure. Excessive compression of a lung lobe with fascia appears to be dangerous. If the amount of fascia is insufficient, the process should be limited to partial enclosure of the selected lobe. The best results were obtained with a large piece of fascia which enabled us to maintain the lung in a position of spontaneous relaxation, thus avoiding dangerous compression. The operation was well tolerated, the free transplant always took, and there was no pleural exudate. In two dogs sacrificed 3 months after the operation, pleural adhesions fixed the atelectatic lobe to the chest wall. These adhesions, however, did not interfere with centripetal retraction of the enclosed lobe which was completely atelectatic. Examination of the specimens showed that there was no obstruction of the primary bronchi. Thus the mechanism of production of this form of collapse is different from that of the other method, i.e., bronchial ligation. As a rule there was no displacement of the mediastinum but whenever it occurred it was not pronounced. The bronchial ligation was technically the easier operation.

Four days after the operation was the shortest period after which a ligated lobe was examined and the lung appeared already atelectatic at that time. However, the ligated lobe continued to decrease in size and increase in consistency when more time had elapsed following ligation. The bronchial lumen was completely occluded at the point of ligation. The bronchi immediately distal to the ligation appeared somewhat dilated and filled with mucus. Microscopic examination revealed the peripheral bronchi compressed, the lumen being much reduced in size. The alveoli were airless and a passive congestion of the tissues existed. The displacement of the surrounding structures (mediastinum, diaphragm, etc.) was very much less pronounced when only one lobe was occluded than when the whole lung was ligated. It is well to remember in this connection that the mediastinum of the dog is very movable, especially much more than the same structure in the human. After careful studies it is today well known that the functional compensation of the remaining tissue is sufficient even in the case of abalation of an entire lung.

The results of collapse therapy in pulmonary tuberculosis are not always those desirable. In 1128 cases studied by Ulrici, only 23 per cent of ten year cures were obtained. Consequently the trial of new methods is justifiable.

Theoretically, fascial collapse should have some advantages over a pneumothorax, i.e., a more complete continuous rest of the diseased part, a true selective collapse limited to the tuberculous lobe, no reactivation of the process after re-expansion of the lung, a shorter period of treatment (social problem) and probably like the other methods of constant collapse (thoracoplasty) more permanent cures.

Thoracoplasty does not completely relax the lung since the intrapleural pressure remains negative. Also its compression is exerted mainly in one direction, i.e., from the side. There is the danger of mediastinal displacement and the compression of the heart and its great vessels, and finally thoracoplasty is a traumatizing and deforming operation.

The fascial collapse maintains complete relaxation of the lobe and produces a centripetal collapse in all directions of the affected lobe. The compression is independent of the mediastinal instability, the procedure is not traumatic, and does not alter the form of the chest. In cases of so called hanging cavities or in which the thoracoplasty fails to produce complete collapse of the cavity a clinical trial of fascial collapse is justifiable.

SUMMARY

Two methods of producing collapse of the lung have been described. One consisted of surrounding a lung lobe with an envelop of living fascial transplant. The other entailed the double ligation of a primary bronchus, avoiding the bronchial arteries, and the injection of a solution of silver nitrate between the ligatures. Massive atelectasis of the lung tissue was obtained with both methods but, in the case of the fascial transplant, the bronchial passage was maintained intact. The procedures were not complicated by the development of a pleural exudate. A clinical trial of the fascial type of collapse is justifiable in cases of hanging cavities or in uncollapsed cavities following thoracoplasty.

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THE PHYSIOLOGY OF THE UTERINE MUSCULATURE

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OUR knowledge of the physiology of muscle has advanced considerably since the time that the phenomena of contraction, retraction, and polarity as manifested by the uterus were discussed by Dubois and Pajot, Duncan, Galabin, Horrock, and Cazeaux. In this paper we desire to analyze the different types of activity of the uterine musculature, in the light of modern physiologic concepts and terminology. Such a consideration delineates certain problems bearing on the interpretation of certain abnormal states of uterine motor activity.

During the course of our study of the comparative physiology of the uterus (35), we have become more and more conscious of the need of terms with which to describe accurately the physiologic changes manifested by the muscle fibers of different portions of the uterus acting simultaneously. The term "retraction," although it is descriptive of what occurs in the upper uterine segment as a whole in labor, is not descriptive of the change occurring in the individual muscle fibers. In the lower uterine segment relaxation of the muscle fibers occurs in a gradual step-like manner. They are not completely relaxed because they are able to resist stretch in an active manner. It is stated generally that the lower uterine segment is stretched and thinned, but this does not describe the change in the individual muscle fibers. The change that occurs in the lower uterine segment as a whole might be referred to as "receptive relaxation," or "postural relaxation," terms that have been used to describe, for example, the relaxation that occurs in the fundus of the stomach and other parts of the gastro-intestinal tract when material enters. Such terms are descriptive of the process as a whole but do not tell us that the muscle fibers have elongated and become relatively fixed at an increased length, under which condition they manifest the same tension, or as some would say, the same "tone." The term "tone" has been given so many connotations that it has become necessary to qualify it, and many students of muscle physiology at the present time avoid the use of the term because of the confusion it engenders.

In our previous papers on the comparative physiology of the uterus, we have attempted to avoid the use of the term "tone" in so far as possible. Because of the lack of an adequate descriptive physiologic term, with which to describe the change of the muscle fibers of the upper uterine segment in labor which results in the phenomenon of "retraction," we have referred to it as an isometric contraction which is inexact and which, if adhered to, would give a new connotation to the term. For these reasons, we believe that it is timely to discuss the subject of the physiology of the uterine musculature and to seek more adequate and exact descriptive terms of the changes manifested.

The uterus from the beginning of pregnancy undergoes definite physiologic changes which on the biologic principles of adaptation are directed toward the expulsion of the products of conception at term. In the non-pregnant uterus, Aschoff's anatomic division is useful in its application to the physiologic changes that occur in pregnancy. He holds that in the non-pregnant uterus, a narrow portion, the isthmus uteri, usually separates the uterine cavity from the cervical canal. He proposed to call the upper opening of the isthmus uteri, the anatomic os internum, and the lower opening the histologic, or the true os internum, the intervening structure becoming the lower uterine segment during pregnancy and parturition. The anatomic os internum would, therefore, correspond to the retraction ring of Barbour and Lusk, contraction ring of Schroeder, or what we prefer to call the "fundal ring," or the physiologic retraction ring, on biologic grounds (35). The portion of the uterus above this physiologic retraction ring

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is referred to as the upper uterine segment during pregnancy and parturition.

The first response of the uterus after the nidation of the fertilized ovum is hypertrophy, and some hyperplasia of its muscular fibers. This brings about an enlargement of the uterus which is greater than the demand of the growing ovum in the first trimester of pregnancy. This hypertrophy is due to humoral factors. From the fourth month of pregnancy to term, the products of conception are in contact with the walls of the uterine cavity (24), so that the enlargement of the uterus may be brought about either mechanically by the growing fetus (13, 21, 22, 27, 39, 41), or chemically by humoral factors (6, 7, 10, 37), or a combination of both (12, 13, 26, 28). The hypertrophy of the uterine musculature involves obviously the musculature of the entire uterus. These structural changes in the uterus are associated with certain definite adaptive readjustments which manifest themselves prior to, and during parturition. This consists in the development of the two physiologically different segments. These segments have been designated as the upper and the lower uterine segments during the formative periods of the uterus in pregnancy and during parturition. The division of the uterus into an upper and lower uterine segment is an essential process for parturition because one observes an "anatomic" and functional difference between these parts of the uterus during the different stages of labor. The functional differentiation can be demonstrated by a comparative study of parturition in the dog, rabbit, and sheep (34),and in the monkey (19), and is generally recognized among obstetricians. This functional differentiation of the uterus in all species is dependent upon the physiologic properties of the muscular fibers of the upper and lower uterine segments.

The usual obstetric terms used to describe the muscular activity of the uterus are as follows: The upper uterine segment is the active segment, and its muscular changes during parturition consist of contraction and retraction or thickening, or "capping." The lower uterine segment is the so-called passive segment, and its muscular changes during parturition consist of relaxation, stretching, or thinning.

At this point, it is necessary to describe certain phenomena characteristic of muscle activity. First, it must be remembered that the processes of contraction and relaxation are not instantaneous, but occur gradually. Second, when the contracting muscle is permitted to shorten and raise a weight, the contraction is said to be *isotonic*, because the tension on the muscle remains constant during the process of contraction and relaxation. Third, when a muscle is acting on a weight which it cannot move, the muscle does not shorten appreciably. The tension exerted by the muscle increases to a maximum and then declines. Such a contraction is said to be *isometric*. Fourth, a contraction may be *isometric* for a portion of its period and *isotonic* during the remainder, or vice versa. Fifth, when a contraction occurs against a gradually increasing resistance, but still moves an object, the contraction is said to be *auxotonic*. For example, the ventricles of the heart contract *isometrically* until the aortic valves open, and then contract *auxotonically* until the systolic height is reached. In general, the length of the *isometric period* depends on the aortic pressure. The contractions of the uterine musculature in labor are obviously chiefly isometric and auxotonic in type. Sixth, *tone*, or *tonus*, is a term that has been used since the time of Galen and has numerous connotations. Some physiologists think the term should be discarded, particularly when considering cardiac and skeletal muscle. *Tone*, as applied to *smooth muscle*, is generally defined as a *state of sustained contraction* (due to persistent excitation) which varies in duration and degree, and, though modified by, is usually maintained independent of, extrinsic nerve centers. The degree of tone is determined by the resistance to extension. If *tone* becomes very marked and persistent and produces abnormal tension or pressure effects, it is referred to as *spasm*. The terms hypertonus, tetany, and spasm imply not only a sustained shortening of smooth muscle but also increased tension or rise in pressure within a hollow viscus, or that portion of the viscus affected. *But the smooth muscle of a hollow organ may shorten and manifest sustained shortening without an increase in luminal pressure, provided there is a proportional*

decrease in the volume of its contents. It is well known that the stomach, intestines, colon, urinary bladder, and uterus may adjust their musculature so that widely different volumes are accommodated without a change in pressure. Thus, we must either dismiss the connotation of "tension" from our idea of tonus, or avoid using the term in speaking of such reactions in viscera. This type of tone has been called "postural tone." The sustained shortening of muscle fibers which leads to a postural change has been called a *postural contraction* (Sherrington), and a sustained lengthening has been referred to as *postural relaxation.* The term *postural tone* as applied to the uterus is useful in that the shape, contour, and posture of the uterus depends primarily on the anatomic arrangement and the relative fixation of length (*metrostasis*) of its muscle fibers. The term "postural tone" is also useful in explaining the fact that in labor and after the third stage of labor the uterus tends to assume its original flattened form. The concept is also useful in appreciating how, in the presence of normal anatomic development, but in the absence of a normally functioning co-ordinating mechanism, changes in contour or shape may result from an imbalance or a disturbance of the postural adjustment of the muscle fibers in different parts of the uterus. But the terms "postural contraction" and "postural relaxation" do not adequately describe, in the case of the uterus in labor, the change that occurs in the muscle fibers during the process of thickening of the upper uterine segment and the dilation and effacement of the cervix. Neither do these terms describe the changes that the muscle fibers undergo in the process of producing the changes in shape or posture of the uterus in labor. These changes in the individual muscle fibers are changes in length which become relatively fixed. Whether fixed at an increased length or decreased length, the tension is approximately the same.

"Metrostasis" is a term that may be used to designate a relative fixation of length without a change in tension. The term does not designate the direction of the change in length. To denote a fixation of length without a change in tension and at the same time denote the direction of the changes in length, two terms are necessary. We suggest and shall use the term "brachystatic contraction" (brachystasis, meaning a relative fixation at shorter length) to denote the process in which the muscle after contracting does not relax to its original length and becomes relatively fixed at a shorter length and in which state it manifests the same tension. The term "mecystatic contraction" will be used to denote the process in which the muscle relaxes or elongates and becomes relatively fixed at an increased length and in which state it manifests the same tension. Thus, when the urinary bladder, which we shall say contains 400 cubic centimeters of urine at a pressure of 10 centimeters of water, expels a portion of the urine, we shall say 200 cubic centimeters, and then the flow is cut off before evacuation is complete, and after a short time the muscle adjusts itself to the new volume so that the pressure is again about 10 centimeters of water pressure, we may say that the bladder muscle has undergone a metrostatic adjustment, or denoting the direction of changes in length in this case, a brachystatic adjustment. During the first and second stage of labor, the upper uterine segment normally becomes thicker due to a sustained shortening or brachystasis of the muscle fibers. A successive increase in brachystasis results, leading to the phenomenon of "retraction." Conversely, the lower uterine segment becomes somewhat thinner due to a gradual increase in length, or mecystasis of its muscle fibers. In other words, the muscle fibers of the upper uterine segment manifest brachystatic contraction, and of the cervix and the lower uterine segment, mecystatic relaxation, the intra-uterine pressure remaining approximately the same during the interval between the easily detected "uterine contractions" or "uterine pains." The term "retraction" describes what occurs in the upper uterine segment as a whole and is a useful term. But the term "retractile tone" is not descriptive of the change occurring in the individual muscle fiber.

To state that the "retraction" of the upper uterine segment is due to brachystatic shortening or contraction of its muscle fibers is a more exact and descriptive statement. Brachystasis as manifested by the smooth muscle

of most hollow viscera is more or less temporary. In the uterus, however, it is normally relatively permanent, in that after birth of the products of conception, the uterus remains in a brachystatic state (or a "retracted state").

All muscle fibers in a portion of the uterus or in different layers may not manifest the same degree of brachystasis. For example, in the dog after the lowermost ampulla has been evacuated, the brachystasis of the longitudinal muscle fibers persists, but the circular fibers manifest mecystasis so that the next fetus may descend through the evacuated ampulla.

Another fact of muscle physiology, which is applicable to the smooth muscle of the uterus as observed obstetrically, is that the *power of developing tension is lost as the result of shortening* (Starling's law of the heart: the energy of contraction is a function of the length of the muscle fibers.) (38). For example, when the fetal head becomes arrested in the pelvis and the contractions of the uterus continue so that the retraction or brachystasis of the upper uterine segment becomes very marked, the contractions of the upper uterine segment produce less tension than they were capable of producing before they had undergone such marked shortening. Another generalization of muscle physiology is the smaller the shortening permitted, the greater the tension developed and the longer the duration of the response. We do not know whether this is applicable to the uterus or not, but it probably is.

The phenomenon of smooth muscle, which permits a relative fixation at different lengths and in which state it may still contract and relax has been compared to a ratchet mechanism. The mechanism by which a sustained relatively fixed increase or decrease in length of the muscle fiber is maintained is not known. It is known, however, that this state of sustained fixation of length does not lead to an appreciable increase in the expenditure of energy, or in metabolism, and is relatively indefatigable. Oxygen is necessary to maintain the brachystasis of smooth muscle, but the oxygen consumption during brachystasis is less than during the relaxed state (Evans, 38). This fact has suggested the idea that this economic phenomenon may be due to a change in the physical state of the muscle plasm, it being supposed that some part or all of the muscle plasm becomes less fluid or more gelatinous. The consideration of these statements obviously has an important bearing on the problem of so called uterine exhaustion and inertia.

Summarizing, it is known that smooth muscle, besides contracting isotonically, isometrically, and auxotonically, is able through the phenomenon of metrostasis, or of brachystasis and of mecystasis, to maintain itself economically at different lengths while exerting the same tension. It is through the manifestation of brachystasis and mecystasis by the smooth muscle of a hollow viscus that the viscus may adapt itself to different contents and manifest differences in form or posture without changes in intravisceral tension. In the case of the uterus, the upper uterine segment thickens by contracting brachystatically and the lower uterine segment thins and the cervix dilates by relaxing mecystatically in a co-ordinated manner to bring about the physiological purpose of uterine contractions, namely, the expulsion of the products of conception from the uterus.

The object of the remainder of this paper is to apply these terms, or concepts, to the muscular changes which occur in the uterus prior to, during, and after, labor.

General remarks. Because of hydrostatic principles, it is unlikely that a true isotonic contraction ever occurs in the uterus, especially as long as the "bag of waters" is intact, because it is difficult to imagine a contraction occurring without an increase in tension in the uterine cavity. While the head or body is being born, it is possible for an isotonic contraction to occur for a brief period during the final contraction leading to the birth of these parts. For example, as the trunk is being born there is a brief period during which the rate of shortening of the uterine muscle follows the rate of descent of the trunk so that the tension exerted remains the same.

BRAXTON-HICKS INTERMITTENT UTERINE CONTRACTIONS

Graphic records of the intermittent uterine contractions during pregnancy (36th week) have been made by Bourne and Bell in one patient. The contractions were quite similar

to those observed during the early stage of labor. During a Braxton-Hicks contraction, the contraction occurs against a gradually increasing intra-uterine pressure until a plateau is reached when the contraction for a brief period continues without a change in pressure and length and then relaxation results. They may be compared to the rhythmic contractions of the distended urinary bladder. They are chiefly isometric in character in the sense that nothing is moved, no physical work is performed, and that only the tension exerted by the muscle on the contents is increased.

During labor. First stage. With the onset of labor, the muscle fibers of the upper uterine segment contract auxotonically until such resistance is met that appreciable shortening of the fibers does not occur. Then the contraction becomes isometric, nothing is moved. Then relaxation occurs, but the muscle fibers do not return to their original length, or in other words, the muscle fibers manifest brachystasis. (As in true hunger pains, the pain of vigorous uterine contractions is experienced after the contraction is well under way and may persist for a short time after relaxation, or the return to the original intra-uterine pressure). The records of Schatz, Bourne and Burn, and Moir show that after relaxation has occurred, the intra-uterine pressure returns to its original level. Since, as the contractions continue, it is known that the upper uterine segment thickens and the cervix is effaced, and since the intra-uterine pressure between contractions returns to "normal," the brachystatic contraction of the upper uterine segment bears a reciprocal relationship to the mecystatic relaxation of the cervix and the lower uterine segment. That is, during the first stage, the upper uterine segment "retracts" only to the extent that the cervix and lower uterine segment "gives" or relaxes. (One must recall at this point that a mecystatically relaxed muscle still manifests "tone," still resists stretch, and that it may contract on stimulation. It has only increased in length in a ratchet-like manner. A muscle in a mecystatic or brachystatic state may be stretched mechanically, as may occur in the "version procedure," for example; but if stretched suddenly, injury results. Some would say that injury should always result. Sufficient study has not been made to warrant an absolute statement on this point. This does not mean that the state of brachystasis or mecystasis cannot be reversed. Such reversal occurs in the stomach, intestine, and urinary bladder.) The function of the contractions during the first stage is to efface and dilate the cervix. None or but little descent of the presenting part occurs. Descent is a feature of the second stage.

Second stage of labor. Mecystatic relaxation of the lower uterine segment and cervix does not occur during the second stage because dilation of the cervix has been completed. Thus, after the end of the first stage the uterus manifests only contraction and brachystasis. The attachments of the uterovaginal canal have been pulled taut and are kept taut by the brachystasis of the upper uterine segment. Further, the intra-uterine pressure between the contractions is somewhat higher than during the first stage. This means that some "incomplete tetany" or spasm is present. This may be a normal or an abnormal phenomenon, since it is shown in the records of Schatz, but not in those of Bourne and Burn until they gave pituitrin. (Here again we have an analogy to hunger contractions in the stomach. As a hunger period progresses, the intragastric tension manifested between the individual hunger contractions is increased, until finally the hunger period is usually ended by a brief period of gastric tetany or spasm.) Before one may state definitely that the incomplete tetanus of the uterus shown by Schatz' tracings is a normal phenomenon, more records than those available will be required.

During the second stage of labor, the brachystatic contraction of the upper uterine segment becomes more and more marked as the fetus descends. (In the stomach, brachystatic contraction of the muscle of the fundus becomes progressively greater as the fundus empties.) With the cervix fully dilated, lever action of the lower muscular pole of the uterus working against the head is gone, and the "pull" of the uterine contraction is now exerted primarily on the attachments of the vaginal canal. Obviously, after effacement and dilatation are complete, mecystatic relaxation of the lower uterine segment should and

does not normally occur; the muscle fibers should not elongate, but should hold stationary until the upper uterine segment expels the fetus from its lumen. Then the lower uterine segment should contract to a certain extent to expel the hind parts of the fetus, which actually occurs, according to direct observation in the dog, rabbit, and monkey.

Obstetrically, in the second stage of labor, the following sequence of events is observed: the contraction is observed to start; after a few seconds, the head begins to descend; then the descent practically ceases, though the contraction persists; as the contraction disappears, the head rises slightly. This may be interpreted to mean that the uterus first contracts isometrically (the head does not descend); and after a certain tension is reached, the head begins to descend, so that the contraction is now auxotonic (head descends against increasing resistance); then, the tension becomes insufficient to overcome appreciably the resistance and the contraction is isometric; then, the uterus relaxes and the head ascends slightly, but the head does not return to its original position because brachystasis occurs in the upper uterine segment.

The apparent temporary uterine arrest which follows the birth of the head for a brief period, probably indicates that several contractions of the uterus must occur, or some time must elapse, to permit sufficient brachystatic contraction to result to bring the uterine musculature firmly against the hind parts, and again to pull taut the uterovaginal attachments. That this is in part true is indicated by the fact that, after the birth of the head, the cervix becomes smaller, contracting about the neck, and then dilates again about the shoulders as the evident contractions start. Or, the apparent inertia may be due to what physiologists (17) call an "incomplete tetanus," slow relaxation, or a "contraction remainder." According to our observations (34, 35) on the dog both factors are concerned and a true inertia does not exist at this time. This temporary apparent "inertia" is probably analogous to the usually more prolonged "inertia" that follows the second stage.

The erection, or anterior movement, that the uterus undergoes during each contraction is due to the fact that associated with the formation of the lower uterine segment and the effacement and dilatation of the cervix, the structures of the posterior vaginal canal "give" more. The manifestation of this phenomenon is primarily dependent on the greater relative fixation of the anterior lip than the posterior lip of the cervix. It is not reasonable to believe, in view of the obstetrical facts, that the anterior uterine muscle is stronger than the posterior (33).

As dilatation of the cervix is the important criterion of the efficiency of the uterus in the first stage, the descent of the head is obviously the important criterion of the expulsive efficiency of the uterus during the second stage. The amount of descent with each uterine contraction is the resultant of the expulsive efficiency of the contraction and the resistance offered by the structures of the birth canal (vagina and pelvic diaphragm), because opposing forces are concerned. The upper uterine segment as a co-ordinated unit must contract first auxotonically and then isometrically in order to dilate the birth canal. If the isometric, or plateau, period of the contraction is of short duration, the dilating efficiency of the contraction is reduced. After the contraction, brachystasis of the fibers of the upper uterine segment, as a unit, must result to conserve the advantage gained. *Without brachystasis sustained descent is impossible.* If brachystasis is not normal, descent will occur slowly, because the efficiency of the subsequent contraction is reduced. In the instance that the fetal head meets with unalterable resistance due to pelvic disproportion, for example, and the upper uterine segment manifests normal contractions and brachystasis, the lower uterine segment having "less musculature" becomes excessively thinned and the upper uterine segment excessively "capped" or retracted. And, the normal physiologic retraction ring (contraction ring of Schroeder or retraction ring of Barbour and Lusk) found at the junction of the upper and lower uterine segment will be converted into a pathologic retraction ring (Bandl's ring).

Third stage of labor. After the delivery of the child, the upper uterine segment usually undergoes, both longitudinally and circularly, a marked "tetanic contraction" plus brachy-

static contraction, which must inevitably result in a separation of the placenta, or the greater part of it, if not all, and in the formation of the retroplacental hematoma. Several contractions may be required, however, to bring about the degree of brachystasis (retraction) necessary to separate the placenta and membranes completely and to close the maternal sinuses. The lower uterine segment which had contracted isotonically or auxotonically as the breech was expelled, relaxes to receive the placenta.

A period is sometimes observed between the birth of the child and the separation of the placenta during which the uterus is firm and does not contract and relax and appears to be in a fixed state in regard to motility. Or, after the placenta has been separated from the upper uterine segment and is present in the lower, the same phenomenon may be observed in the upper uterine segment. Such sustained contractions when they occur in other hollow viscera are referred to as spasm or "incomplete tetanus," preferably the latter. The intact uterus of the dog, monkey, and man (19) manifest the same phenomenon temporarily (2 to 10 minutes) after a dose of pituitrin following which the uterus again contracts auxotonically, gradually relaxing after each contraction until the original intra-uterine pressure is reached. By analogy with the stomach in hunger, in which a vigorous hunger period is completed by the evidence of spasm or tetany (also the irritable urinary bladder), one should regard this phenomenon as due to a temporary spasm or "incomplete tetanus."

After this period of "incomplete tetanus," the upper uterine segment relaxes and its cavity is filled with blood. After a period of inertia, or rest, which varies considerably in length normally, auxotonic contractions appear which expel the placenta and blood, and the uterus becomes temporarily a pelvic organ. Later the uterus relaxes and becomes an abdominal organ, the fundus rising to the level of the umbilicus.

In the dog, brachystasis is evidenced more markedly by the longitudinal than the circular muscle and it is certain that the separation of the placenta is caused, and bleeding from the placental site is controlled, to a much greater extent by brachystasis of the longitudinal than of the circular muscle fibers. In the monkey, brachystasis is as marked in the lower as in the upper uterine segment, and all the muscle fibers appear to be concerned in the separation of the placenta and the control of bleeding from the placental site. In a cesarean section, as soon as the child is delivered, the whole uterus contracts, as may be seen and felt; but in a few minutes the lower uterine segment becomes quite flaccid in contrast to the upper uterine segment which remains firm for a longer but variable period. The lower uterine segment manifests considerable brachystasis as is shown by the fact that it is thicker than it was prior to delivery. The brachystasis of the lower uterine segment is not as marked, apparently, as that which occurs in the upper uterine segment and is not as marked in the human under anesthesia as in the monkey.

After the birth of the placenta under normal conditions, the brachystasis or "retraction" particularly of the upper uterine segment is practically maximal. In spite of the high grade brachystasis it contracts and relaxes rhythmically. This is not only true of the dog and monkey (19, 34), but also of the human (4), the graphic records obtained from the dog and monkey being quite identical to those obtained from the human postpartum uterus (8). These contractions are auxotonic in type rising from a pressure of zero or "the baseline pressure," which depends on the amount of air or water in the balloon, to a pressure which may vary from 5 to 50 millimeters of mercury (human), depending on the animal studied.

DISCUSSION

From the foregoing review, it is evident that uterine muscle manifests primarily four different types of activity during labor, namely, auxotonic and isometric contractions and brachystatic contraction and mecystatic relaxation. One type of activity is as important for parturition as any other. The auxotonic and isometric contractions are responsible for the production of the force that expels the fetus downward. But, without brachystatic contraction to take up the "slack," to hold the advantage gained, and to maintain the uterine

musculature in firm contact with the breach, much of the directed force of the auxotonic and isometric contractions would be lost. Without mecystatic relaxation, i.e., if after each uterine contraction, the musculature of the cervix did not normally relax or elongate to a greater extent than existed before the uterine contraction, excessive force would have to be applied by the upper uterine segment to produce effacement and dilatation of the cervix; and further, if the musculature of the cervix and the lower uterine segment after relaxing or elongating, did not become relatively fixed at an increased length at which it exerted the same tension, the lower uterine segment and cervix would become more rapidly and excessively thinned and dilated by the contractions of the upper segment. Or, in other words, the effacement and dilatation of the cervix uteri is not a mechanical stretching process pure and simple, like stretching so much rubber, but is a true physiologic phenomenon.

In auxotonic and isometric contraction, physical work is performed and energy-producing substances are required. Hence, this type of uterine activity is subject to fatigue or exhaustion. Brachystasis is not only economical in that it conserves the force of the uterine contractions by causing them to be applied most advantageously but, also, in that it does not require an appreciable expenditure of energy for its maintenance and is relatively indefatigable. A consideration of these statements has an important bearing on the problem of uterine exhaustion and inertia uteri and much *progress is not to be expected in this field until more is known concerning the metabolism of uterine muscle.*

It is entirely possible for smooth muscle to manifest auxotonic and isometric contractions without manifesting brachystatic contraction. The obstetrician sees patients in whom the uterine contractions are fairly strong, but in whom no "capping" or thickening of the upper uterine segment occurs. One of the problems in obstetrics is to find a drug or procedure that will stimulate the three types of activity manifested by the upper uterine segment in labor without at the same time interfering with the mecystatic relaxation of the lower uterine segment and cervix or causing localized spasm. Pituitrin and ergot both augment the auxotonic and isometric contractions of the uterus, and may possibly promote brachystasis, for varying periods depending on the dosage and sensitivity of the uterus, but unfortunately, both of these drugs affect the lower uterine segment as much as the upper. This statement, of course, is only relatively true because the upper uterine segment is more powerful. But one can never feel certain that "incomplete tetanus" or tetanus, localized or general, might not occur. A rational therapy for *adynamic uterine inertia* will not be available until we learn more of the fundamental physiology of the uterine musculature.

We do possess two agents which depress or inhibit uterine contractions, namely, ether and epinephrine. The inhibiting action of epinephrine on the uterus *in situ* of the dog and monkey has been graphically demonstrated by Rudolph and Ivy (34) and by Ivy, Hartmann, and Koff (19), and of the human by the work of Bourne and Burn (4), and Rucker (31). Further studies on magnesium and calcium are needed (see Blair-Bell, Datnow and Jeffcoate, (2). But we believe that the problem of *hypertonic uterine dyskinesia* (ill motion) is not solved and awaits the acquisition of further knowledge pertaining to the fundamental physiology of the uterine musculature.

On the basis of general physiologic considerations, the factors concerned in the cause of uterine dysfunction or uterine dyskinesia during labor may be analyzed as follows: *First*, the *extrinsic factors* which operate (a) either through the nerves (nervous) leaving the lumbosacral region or (b) the blood (humoral). Among the nervous influences, fear and anxiety may lead to a hyperkinetic cervix, or an increase in tension of the muscles of the pelvis, or produce an inco-ordination of the power and the harmonious sequence of the activity of the uterine musculature. A direct example of a spino-uterine reflex is the mammo-uterine, or "nipple" reflex. Among the humoral influences that must be thought of are: (a) a disturbance of the excitatory (hormone) and inhibitory (chalone) autacoids (self-remedial substances; internal secretions) that may be concerned in the initiation and progress of labor, as well as the normal development and

differentiation, or the quantitative and qualitative irritability of the gravid uterus (2, 20, 25, 29, 30); (b) changes in the composition of the blood which affect the irritability and contractility of muscle, regardless of the type of muscle, and which occur in such conditions as physical exhaustion, infections or toxemias, starvation, "shock," and changes in functional mineral balances. *Second*, the *intrinsic factors*, which involve (a) qualitative and quantitative disturbance of the muscle fibers due to local disease or abnormal differentiation of the muscle cells due to other factors than extrinsic factors, and (b) disturbances of the intrinsic co-ordinating mechanism. We hesitate to indicate whether the uterine contractions initiated by rupturing the membranes, a bag, or pulling down a leg are due to an intrinsic uterine reflex, or to a spinal reflex. We are inclined to the view on the basis of our animal experiments and the discussions in the literature, that both an intrinsic and an extrinsic reflex mechanism are concerned.

The possible functional types of uterine motor dysfunction, or uterine dyskinesia, which may theoretically occur are suggested in the following outline:

UTERINE DYSKINESIA (ILL MOTION)

I. Hypokinetic uterine dyskinesia; so called uterine inertia.
   a. Adynamic; weak, short contractions; contractions absent or very infrequent. This is the ordinary type of so called uterine inertia.
   b. Abrachystasis; (a "retraction" defect); failure of the muscle fibers in the upper uterine segment to become relatively fixed at a shorter length after each contraction during the first two stages of labor, and after the separation of the placenta. To our knowledge this has never been absolutely demonstrated to occur; theoretically it may and probably does occur.

II. Hyperkinetic uterine dyskinesia
   a. Tetanic: tetany or spasm of the upper uterine segment, or of the entire uterus.
   b. Amecystatic; failure of the muscle fibers of the lower uterine segment to relax and become relatively fixed at an increased length. This would produce the picture of a spastic or hyperkinetic lower uterine segment and cervix uteri.
   c. Constriction rings; occur most likely at points which have "sphincter-like" properties, such as (a) cervix, (b) fundal ring or the physiologic retraction ring, (c) at the phylogenetic constriction zones (32).

III. Arrhythmia
   a. Asynchrony of the pace-maker of the uterus.
   b. Unilateral inertia of the pace-maker of the uterus.
   c. Sacculation—(localized paresis) (that is not due to organic defects).
   d. Ectopic contractions (has not been reported).
   e. Reversed polarity. Webster, Galabin and Blacker.

The well recognized example of hypotonia or adynamic type of uterine dyskinesia is primary or secondary uterine inertia. The contractions are weak and irregular, of short duration, or absent, or very infrequent. When they are weak and of short duration, the isometric phase of contraction is absent, and brachystasis is poor or absent. Bourne and Bell, who made graphic records of the weak, irregular contractions in a case of uterine inertia, describe their records as follows: "It will be noted that the contractions are irregular in force and frequency, and they have pointed apices (absence of isometric phase), indicating a short, snappy effort, during which the uterus does not hold on to its work."

The failure of the muscle fibers of the upper uterine segment to manifest brachystasis—abrachystasis—should be recognized as one type of uterine dyskinesia, because it is possible for a smooth muscle fiber to contract and relax to its original length and not manifest brachystasis. *Some additional factor or type of stimulus, other than that required to produce contraction, must be present in order to produce brachystasis.* What this factor is in the case of smooth muscle is not known. (In the case of skeletal muscle, it appears to depend on the frequency of the nerve impulse originating in the anterior horn cells of the spinal cord—14). Whatever the factor that causes brachystasis may be, it is known that it is absent during the Braxton-Hicks intermittent uterine contractions, except during the last month of pregnancy, when the formation of the lower uterine segment is evident (33). Hence, during labor this factor may be inhibited or totally suppressed and contractions may occur without progress being made, even in the presence of a dilated or a normally dilatable cervix.

From the viewpoint of the comparative physiology of the uterus, one might predict that the parts of the uterus to be affected most commonly by circular spasm or hypertonus would be those regions in which the circular fibers have "sphincter-like" properties. This, of course, is borne out clinically, because in the human, as the literature demonstrates, intra-uterine rings are found in different regions from the internal os to the fundus uteri. Bumm's frozen section of the third stage of labor (5) shows these rings to be present in the uterine cavity at different levels from the external os to the fundus uteri. Just as sphincter hypertonus or spasm leads to abnormal motor activity and evacuation in other hollow viscera, the same is true of the uterus. One might predict that the part of the uterus to manifest spasm or hypertonus most commonly would be the cervix (cervical sphincter in the dog and monkey) and the physiologic retraction ring (fundal sphincter in the dog) or the site of junction of the upper and lower uterine segments (32). This, of course, is true clinically of the human uterus. As is true of abnormal motor states of other hollow viscera, constriction rings may occur at almost any point, or the entire musculature of the viscus may manifest spasm or a spastic tendency.

Since a co-ordinating mechanism undoubtedly exists in the uterus (35) and "pacemakers" are probably present (19), various types of inco-ordination may result. The "pace-makers" may discharge synchronously, or either one or both may not act at all, or a functional block in the co-ordinating mechanism may occur, or, because of some change in the irritability or refractory period, the circular, longitudinal, and oblique muscles may not contract synchronously (called arrhymia-colicky uterus—by Dutta). Or, ectopic contractions may occur. We (35) have ascribed certain types of obliquity and sacculation to a disturbance of the co-ordinating mechanism—those types of obliquity which respond rather quickly to therapeutic procedures and in which a fundamental defect in the musculature could not have been the fault. Undoubtedly in the other types of uterine dyskinesia the co-ordinating mechanism may be involved either on the basis of cause or effect.

SUMMARY

In this paper we have tried to emphasize the time honored concept that uterine "retraction" and "contraction" are two distinct processes both of which are necessary for the evacuation of the uterus. "Retraction," in the first stage of labor, leads primarily to a readjustment of the muscle fibers of the uterus whereby the uterus prepares itself for evacuation, and in the second stage, maintains the uterine musculature in firm contact with the breech without a significant change in intra-uterine tension. "Retraction" is an economical and a relatively non-energy consuming process, whereas, "contraction" is an energy-consuming process. In introducing the term "brachystasis" or "brachystatic contraction," we have in mind a more exact term which describes the change which the muscle fibers undergo in order to manifest the phenomenon of "retraction." In addition, we have introduced the term "mecystasis" or "mecystatic relaxation" to describe more accurately, we believe, the change that the muscle fibers of the cervix and the lower uterine segment manifest primarily during the first stage of labor, although a certain degree of "mecystatic relaxation" of the lower uterine segment undoubtedly occurs during the latter months of pregnancy and in part explains the phenomenon of "lightening," and during the third stage of labor after the separation of the placenta and before its expulsion.

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THE SURGICAL ANATOMY OF THE SUPERIOR HYPOGASTRIC PLEXUS—"PRE-SACRAL NERVE"

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THE superior hypogastric plexus first attracted surgical attention in 1924, when Cotte practiced its resection for the relief of pelvic pain.

Frankenhaeuser, in 1867, had published a detailed account of the nerve supply to the female pelvic organs. He described large plexuses in the broad ligaments that consist of fibers from the hypogastric as well as from the sacral plexuses. He subdivided the hypogastric plexus into an inferior hypogastric plexus and a "plexus uterinus magnus," the latter of which is now known as the superior hypogastric plexus. Latarjet and Bonnet (1913) considered the plexus a single nerve trunk to which they gave the name "presacral nerve." Numbers of other investigators have since contributed to the knowledge of the anatomy of this plexus, among them, in Europe, Morrisson-Lacombe (1920), Roussel (1926), Segond (1926), Delmas and Laux (1927), Hovelacque (1927), Bergier (1930), Chianello (1930), Elaut (1932), Fontaine and Herrmann (1932), Davis (1934) and Dobrzaniecki and Serafin (1934) and, in the United States, Learmonth (1931), Douglass (1934), and Kindel (1935).

Prior to Cotte's practice of resection of the superior hypogastric plexus for the relief of pelvic pain, periarterial sympathectomy of the hypogastric and common iliac arteries was the popular procedure. After 1925 Cotte's simpler operation became the operation of choice. Today resection of the superior hypogastric plexus is employed in any of the following:

A. In patients with no demonstrable pathological changes in the pelvis.
   1. Intractable functional dysmenorrhea (Cotte, Fontaine and Herrmann, Leriche, Elaut, Cannaday, Abbott, Adson and Masson, Keene, Counseller and Craig, Wetherell and others).

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B. In patients with slight pathological changes in the pelvis.
   1. Persistent pelvic pain following previous operations (Fontaine and Herrmann, Pemberton).
   2. Scleroscystic degeneration of the ovaries (Fontaine and Herrmann, Lhermitte and Dupont, Cotte).
C. In patients with advanced pathological changes in the pelvis.
   1. Inoperable carcinoma of pelvic organs (Greenhill and Schmitz, Behney, Jianu, Fontaine and Herrmann, Pemberton).
D. Disorders of the lower genital tract.
   1. Pruritis vulvæ (Leriche, Cotte, Simon, Cottalorda and Gavaudan).
   2. Vaginism (Jaboulay, Olivier).
   3. Dyspareunia (Jaboulay, Tassovatz).
E. Various disorders of the urinary bladder.
   1. "Cord bladder" (Learmonth, Fulcher, Cannaday).
   2. Spasm of bladder neck (Douglass, Learmonth).
   3. Intractable cystalgia (Douglass, Learmonth, Rochet, Pieri).
F. In patients with disorders of function of lower bowel.
   1. Hirschsprung's disease (Abbott).
   2. Obstipation of rectal origin (Abbott, Wetherell).

METHOD OF STUDY

Dissections were made first on the cat and rabbit to obtain practical knowledge of the sympathetic nervous system. Later, through the courtesy of Professor G. J. Noback, a series of six human dissections was made in the anatomical laboratories of the Graduate School of New York University. In each case the entire abdominal sympathetic nervous system was exposed. Casts were made at various stages of the dissection by employing the method devised by I. Rehman and G. J. Noback. The final cast was a composite of the aortic plexus, the superior hypogastric plexus, the ovarian and renal plexuses, and the lumbar sympathetic trunks (Fig. 6). The exact communications of the abdominal sympathetic plexuses with the main ganglionated sympathetic trunk were studied, trac-

ing the fibers from their origin to their ultimate distribution in the female reproductive organs.

Following this detailed preliminary study, observations on the anatomy of the superior hypogastric plexus were made on 69 subjects investigated by necropsy. Thus a total of 75 dissections were done. Twenty-three of these were in adults. Fifty-two were in infants ranging from 20 to 40 weeks' gestation. There were 38 males and 37 females in this series.

AFFERENT COMPONENTS

The afferent (sensory) fibers probably pursue a course similar to the afferent (motor) nerves with the exception of a detour via the posterior roots to reach the sensory nerve cell in the posterior root ganglion.

The afferent nerves from the ovary travel in the ovarian plexus along the course of the ovarian artery and ultimately reach the spinal cord at the level of the tenth thoracic segment (Kuntz). Recent experimental evidence in the cat (Labate and Reynolds) as applied to the sensory pathways of the ovarian plexus shows:

a. The sensory fibers arise near the various peripheral branches of the ovarian artery and follow its course closely.

b. The afferent fibers enter fourth lumbar sympathetic ganglion, then traverse upward through the third lumbar ganglion to reach a higher level in the main sympathetic trunk.

c. The ovarian afferent components have no connection by way of the superior hypogastric plexus, nor do they traverse the inferior mesenteric ganglia or the lower aortic plexus.

The afferent fibers from the fallopian tube enter the cord at the level of the eleventh thoracic to first lumbar segments (Kuntz). Most of these fibers probably course through the superior hypogastric plexus. Some of the afferent fibers from the tube also pass through the ovarian plexus (Labate and Reynolds).

The afferent fibers from the uterus reach the cord at the level of the tenth thoracic to first lumbar segments (Kuntz). These fibers pass through the superior hypogastric plexus.

MOTOR COMPONENTS OF THE SUPERIOR HYPOGASTRIC PLEXUS

Two or more parallel nerve bundles are arranged over the anterolateral surface of the aorta, usually one or perhaps two on each side. These are known as the intermesenteric nerves (Petit-Dutaillis and Flandrin). They originate from the inferior pole of the celiac plexus at the level of the superior mesenteric artery and descend over the anterolateral surface of the aorta. Below the point of bifurcation of the abdominal aorta into the right and left common iliac arteries, the intermesenteric nerves become the main components of a triangular shaped plexus—the so called superior hypogastric plexus (Figs. 1 to 8). This plexus descends for a distance of 6 to 8 centimeters, overlying the lumbar vertebræ in the space between the right and left common iliac arteries. Over the middle of the first sacral vertebra the superior hypogastric plexus divides into a right and a left inferior hypogastric nerve (Figs. 1, 3, 6). Each of these continues downward to the lateral rectal space where it ends in the inferior hypogastric plexus. From the inferior hypogastric plexus fibers are distributed peripherally to the pelvic viscera (Fig. 8).

The intermesenteric nerves, extending over the anterior surface of the abdominal aorta from the origin of the inferior mesenteric artery, are connected by numerous anastomoses of nerve fibers, resulting in the formation of the aortic or intermesenteric plexus (Figs. 1 to 6). As each intermesenteric nerve descends over the aorta it also receives peripheral rami from the lumbar sympathetic ganglia (Fig. 3).

Hovelacque regards the superior hypogastric plexus as a continuation of the mesenteric plexus below the inferior mesenteric artery. Delmas and Laux believe that the important branches to this plexus are derived from the lumbar sympathetic chains and that the fibers from the first and second lumbar ganglia are the principal roots to the intermesenteric plexus. In my dissections of infants the prominence of these fibers was apparent, but in the adult dissections the branches from the lumbar ganglia appeared to be less conspicuous, and it was obvious that the main components of the superior hypogastric plexus were derived from the intermesenteric nerves.

The right intermesenteric nerve crosses the right common iliac artery close to its point of

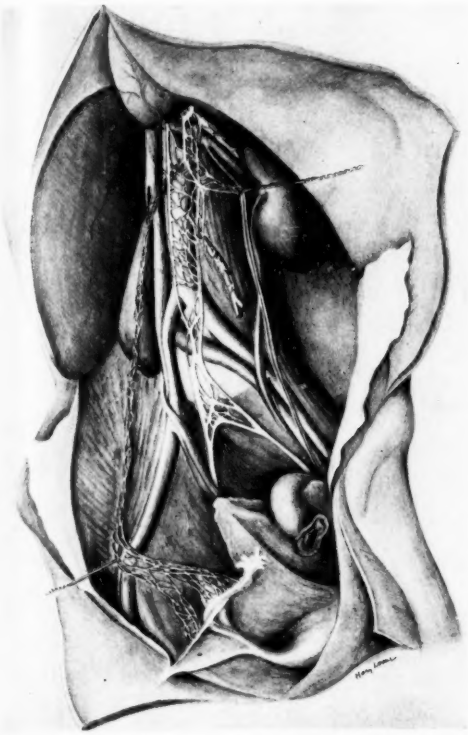

Fig. 1. Dissection to show the abdominal sympathetic plexuses. Note the method of formation and triangular structure of the superior hypogastric plexus. The ovarian plexus on the left has been dissected throughout the course of the ovarian artery extending into the infundibulopelvic ligament.

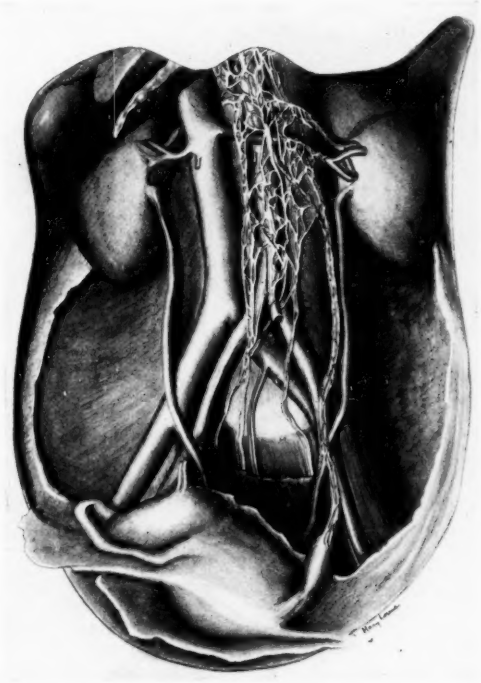

Fig. 2. Dissection showing the abdominal sympathetic plexuses. Here the superior hypogastric plexus is represented by bilateral nerve trunks which descend through the interiliac trigone. Note the density of the aortic (intermesenteric) plexus.

origin from the aorta. The nerve then bends toward the midline and continues downward through the interiliac space overlying the lumbar vertebræ (Figs. 1, 6). The left intermesenteric nerve runs beneath the inferior mesenteric artery. As it passes beneath that artery it gives off several branches to the inferior mesenteric plexus. The left intermesenteric nerve then continues inferiorly, crosses the left common iliac vein and runs parallel with, and about one-half to 1 centimeter to the left of, the right intermesenteric nerve (Figs. 1, 4, 6). The right and left intermesenteric nerve bundles below the bifurcation of the aorta are connected by oblique anastomoses to form the superior hypogastric plexus. Due to the gradual divergence of the main nerve bundles to terminate in the inferior hypogastric nerves, the shape of the plexus is usually triangular (Figs. 1, 4, 6).

In 8 per cent of the present series of 75 dissections, the intermesenteric nerves continued downward below the bifurcation of the aorta in parallel fashion without plexus formation (Figs. 2, 12).

In 8 per cent the intermesenteric nerves united below the aortic bifurcation to form a central nerve bundle, which descended through the interiliac trigone.

Rami from the lumbar sympathetic ganglia. Each intermesenteric nerve receives peripheral rami from the lumbar sympathetic ganglia (Fig. 3). The ramus from the first lumbar ganglion runs obliquely downward beneath the renal artery to join the intermesenteric

Fig. 3. Dissection to show the rami communicating between the lumbar sympathetic trunk and the aortic plexus.

nerve at the level of the third lumbar vertebra. Two rami may arise from the second lumbar ganglion. The rami soon fuse to form a single nerve which continues downward and medially to join the intermesenteric nerve at the level of the origin of the inferior mesenteric artery. This branch may run directly to the upper pole of the superior hypogastric plexus. The ramus from the third lumbar sympathetic ganglion may join the upper pole of the superior hypogastric plexus or it may join the intermesenteric nerve between the origin of the inferior mesenteric artery and the bifurcation of the aorta. The ramus from the lowest lumbar ganglion runs beneath the inferior vena cava and the right common iliac artery to join the superior hypogastric plexus.

Delmas and Laux believe that the fibers from the first and second lumbar ganglia are the principal roots which strengthen the thin branch from the inferior mesenteric plexus and the branches from the third and fourth lumbar sympathetic ganglia.

Inferior hypogastric plexus. The superior hypogastric plexus divides over the middle of the first sacral vertebra to form the right and left inferior hypogastric nerves. These nerves, 5 to 8 centimeters in length, continue downward and laterally into the lateral rectal spaces. In the right and left pararectal space the inferior hypogastric plexuses are formed (Fig. 8). Each inferior hypogastric plexus represents the continuation of the superior hypogastric plexus along the lateral rectal space, and lies on the anterior surface of the rectum. It is intimately connected with the uterosacral ligaments.

The inferior hypogastric plexus gives rise to subordinate plexuses accompanying the hypogastric artery and its branches, from which visceral branches are given off to the pelvic organs.

THE SURGICAL ANATOMY OF THE SUPERIOR HYPOGASTRIC PLEXUS

The common iliac arteries arise opposite the left side of the middle of the body of the fourth lumbar vertebra at the bifurcation of the aorta. Diverging from each other at an angle of 68 degrees in the female, these arteries divide opposite the iliosacral articulation at the level of the lumbosacral junction to form the external iliac and the hypogastric arteries.

The common iliac arteries form the lateral boundaries of a triangular space. Elaut has called this the "interiliac trigone." The apex of this space is at the bifurcation of the aorta. The base is represented by a line drawn horizontally across the promontory of the sacrum to meet the common iliac arteries where they divide into the external iliac and hypogastric arteries. The roof is formed by the posterior layer of the parietal peritoneum. The floor consists of the fourth and fifth lumbar vertebræ and the upper portion of the first sacral vertebra with their intervening intervertebral discs (Fig. 12).

The interiliac trigone is approximately 6 centimeters in width at the base. The distance vertically from apex to base varies between 6 and 7 centimeters.

Fig. 4. Photograph of an adult dissection showing the abdominal sympathetic plexuses and method of formation and structure of the superior hypogastric plexus. Note relationship of the ureters to the interiliac trigone. The upper third of the superior hypogastric plexus lies over the left common iliac vein.

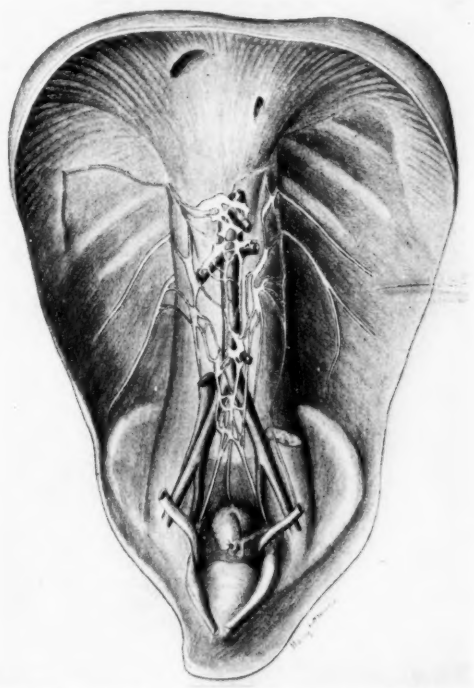

Fig. 5. Cast made of the abdominal sympathetic plexuses in an infant. The rami from the lumbar sympathetic trunks are shown clearly.

The interiliac trigone may be exposed through a vertical incision in the posterior layer of the parietal peritoneum (Fig. 11). The incision is begun at the level of the promontory and extended vertically upward to the level of the aortic bifurcation. By blunt dissection the two peritoneal flaps are reflected laterally as far as the common iliac arteries (Fig. 12). The peritoneum frees easily from the underlying connective tissue layer. Within the firm retroperitoneal connective tissue in the interiliac trigone the nerve fibers of the superior hypogastric plexus are to be found.

The contents of the interiliac trigone consist of the following (Figs. 7, 12): (1) a firm retroperitoneal connective tissue layer; (2) the components of the superior hypogastric plexus closely incorporated into the retroperitoneal connective tissue; (3) the left common iliac vein, which runs obliquely from right to left just below the bifurcation of the aorta; (4) the middle sacral artery and vein, overlying the prevertebral fascia in the midline and behind the connective tissue layer and hypogastric plexus; (5) the right ureter which is exposed as it crosses the right common iliac artery at the level of the bifurcation of that vessel into the external iliac and hypogastric arteries; (6) on the left border of the trigone the inferior mesenteric artery and its sigmoid branch which may be seen entering the root of the pelvic mesocolon.

Variations in the superior hypogastric plexus. The superior hypogastric plexus is essentially a continuation of the intermesenteric plexus below the inferior mesenteric artery. It includes the part of the plexus which extends from the superior part of the fourth lumbar

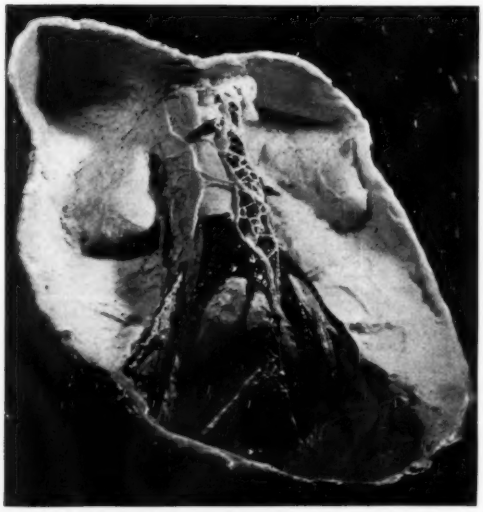

Fig. 6. An adult dissection. Location, structure and method of formation of the superior hypogastric plexus from the intermesenteric nerves are clearly shown. Note the relation of the plexus to the ureters, left common iliac vein, and middle sacral vessels.

vertebra to the middle of the first sacral vertebra. At the middle of the first sacral vertebra the plexus divides into the right and left inferior hypogastric nerves.

The plexus lies embedded in the retroperitoneal connective tissue in the interiliac trigone. After the peritoneal flaps have been reflected laterally to expose the trigone, fibers of the nerve plexus may be seen through the connective and adipose tissues. The fat and connective tissue may be dissected away and the plexus elevated with a blunt instrument. In thin individuals the nerves may be seen through the peritoneum. In its upper portion the plexus lies directly over the left common iliac vein.

The form of the superior hypogastric plexus depends upon the position taken by the intermesenteric nerves in the interiliac trigone. If the right and left intermesenteric nerves unite, a single nerve trunk is formed. If the nerves remain separated they may be joined by anastomoses of small nerve fibers, resulting in the formation of a plexus. However, the nerves may remain as two parallel nerve trunks without any attempt at plexus formation. Thus

TABLE I.—VARIATIONS IN THE SUPERIOR HYPOGASTRIC PLEXUS FOUND IN THIS STUDY

	Adults	Infants	Total	
Plexus type	19	44	63	84
Single nerve	1	5	6	8
Parallel nerves	3	3	6	8
			75	

TABLE II.—ANALYSIS OF THE TYPES OF PLEXUSES

Triangular	29
Narrow	16
Broad	16
Arch shaped	1
Spider web	1

the configuration of the superior hypogastric plexus depends on the degree of convergence of the intermesenteric nerves.

All 3 of these configurations, namely, plexus, single nerve and bilateral parallel nerves, have been found during this study.

The present study includes a total of 75 dissections. On 23 adults and 52 infants the following types of plexus formation were found. A definite plexus was found in 84 per cent (63 cases); a single nerve in 8 per cent (6 cases) and bilateral parallel nerves in 8 per cent (6 cases). (Table I.)

In studying the reports of 309 dissections reported in the literature by various investigators, there was a plexus formation in an average of 70 per cent, a single nerve in 24 per cent, and bilateral nerves in 6 per cent.

Latarjet and Bonnet believed that the plexus is united to form a single nerve trunk, and gave it the name "pre-sacral nerve." Roussel reported a single nerve in 75 per cent and a plexus in 25 per cent. Delmas and Laux found a single nerve in 20 per cent and plexus formation in 80 per cent of his 80 dissections. Ferey reported only 15 per cent of single nerve formations in 13 dissections. Segond and Hovelacque considered the plexus arrangement as predominant. Elaut found a plexus in 58 per cent (29 cases), parallel fibers in 16 per cent (8 cases), a single nerve in 24 per cent (12 cases) and an archshaped plexus in 2 per cent (1 case). Fontaine and Herrmann found that the nerves were usually in the form of a plexus. Kalberg in 38 dissections reported a plexus in 23, a single nerve in 8, and parallel fibers in 7. Learmonth reported a plexus in

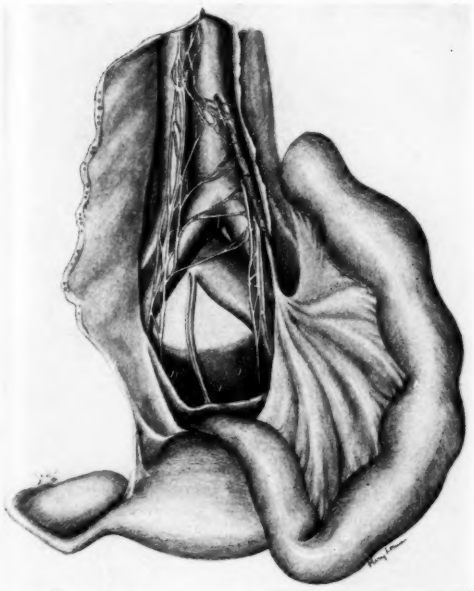

Fig. 7. Dissection of the interiliac trigone to show the contents and structure of the superior hypogastric plexus. Here the plexus is represented by bilateral parallel fibers.

80 per cent, and a single nerve in 20 per cent. Davis in a series of 70 dissections found a plexus in 76 per cent and a single nerve in 24 per cent. Chianello identified a plexus in 53 per cent and a single cord in 22 per cent. Cordier, Jianu, Bernard, Hartmann-Weinberg believe that a plexus arrangement predominates. However, Bergier, Morrisson, and Lacombe consider it a single nerve.

The plexus type occurs most frequently. However, the degree of plexus formation and the length and width of the plexus varies. The structure of the plexus may range from a narrow to a widely meshed plexus occupying a large area of the interiliac trigone (Fig. 9). When the plexus formation does occur it most often assumes a triangular shape. It varies in width from 1 to 2 centimeters. The widest portion of the plexus is situated over the middle of the first sacral vertebra, where bifurcation into the right and left inferior hypogastric nerves usually occurs (Figs. 1, 3). In a smaller number of cases the triangular configuration is less marked (Fig. 9). (Table II.)

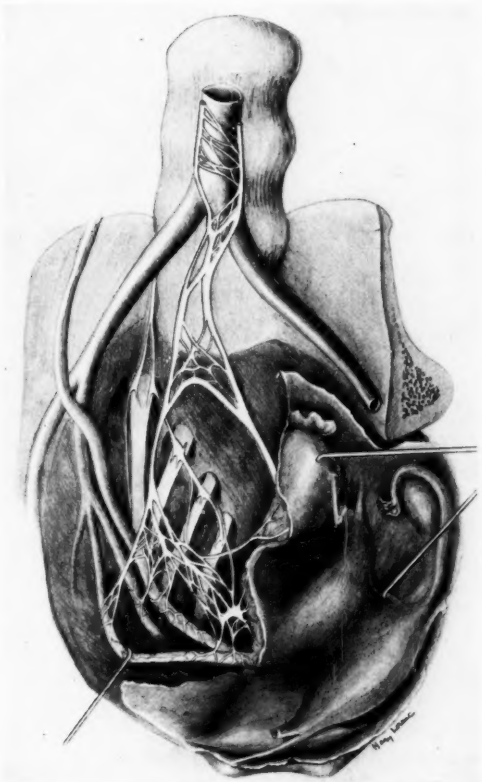

Fig. 8. Dissection showing the bifurcation of the superior hypogastric plexus into right and left inferior hypogastric nerves. In the pararectal space each inferior hypogastric nerve ends in the formation of the inferior hypogastric plexus.

It is not unusual to find the superior hypogastric plexus situated to the left of the midline within the interiliac trigone. This occurred in 10 of the 23 dissections in adults. In 4 of these the plexus was found some distance to the left of the midline close to the left common iliac artery and adjacent to the root of the pelvic mesocolon. The plexus was found overlying the upper portion of the left common iliac vein. It was mistaken for the inferior mesenteric artery, which enters the root of the pelvic mesocolon. In these cases, after the parietal peritoneum was incised, elevation of the pelvic mesocolon raised the inferior mesenteric artery and revealed the

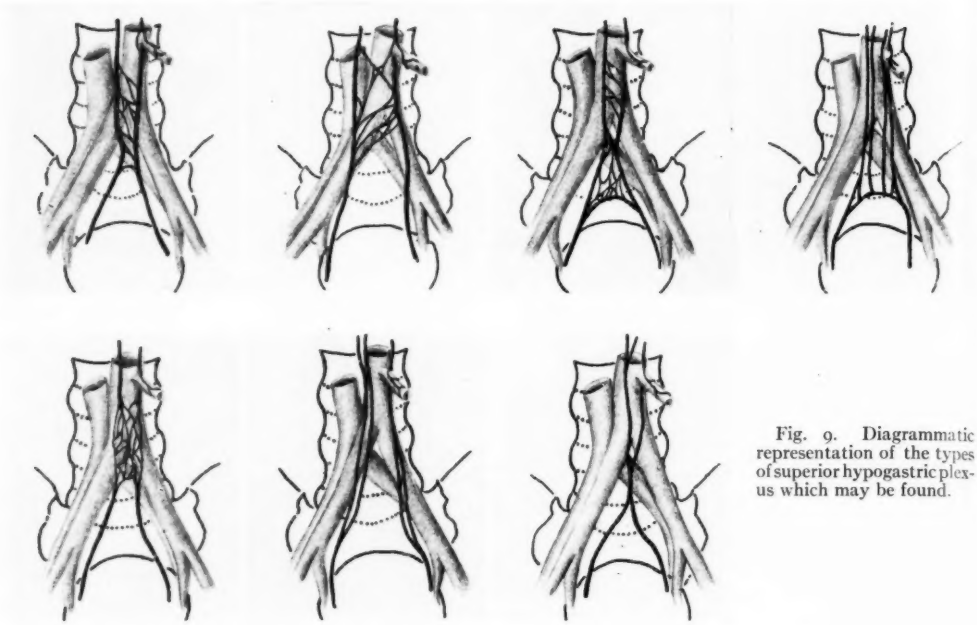

Fig. 9. Diagrammatic representation of the types of superior hypogastric plexus which may be found.

nerves lying over or along the right border of the left common iliac artery. The sigmoid and hemorrhoidal arteries were pushed to the left to expose the nerve plexus clearly.

Dobrzaniecki and Serafin found the plexus to the left of the midline in most cases. The possibility of displacement of the plexus to the left of the midline has not been emphasized by previous investigators.

The superior hypogastric plexus varies from 6 to 8 centimeters in length. It extends from the superior portion of the fourth lumbar vertebra to the middle of the first sacral vertebra. In adults it divides either over the middle or upper border of the first sacral vertebra. Occasionally it divides over the middle of the fifth lumbar vertebra. In infants the point of bifurcation into the inferior hypogastric nerves occurs at a higher level, usually over the lower border of the fourth or fifth lumbar vertebra. Hovelacque gives the middle of the first sacral vertebra as point of termination of the superior hypogastric plexus.

From the above description it is apparent that the sympathetic nerve fibers to the pelvic viscera are collected into an easily accessible bundle in the interiliac trigone. This anatomical arrangement makes sympathectomy simple as a means of operative intervention in certain disorders. As in the sympathetic system elsewhere, the anatomical structure is subject to considerable variations. It is difficult to find two plexuses with the same anatomical architecture.

Middle sacral vessels. Posterior to the superior hypogastric plexus and left common iliac vein, the middle sacral vessels descend through the center of the interiliac trigone.

Over the promontory of the sacrum the connective tissue stroma becomes thinned. The plexus lies on the prevertebral fascia overlying the fifth lumbar vertebra and the intervertebral disc between the fifth lumbar and first sacral vertebræ. Hemorrhage from the middle sacral artery is due, usually, to overzealous denudation of the connective tissue layer overlying the fifth lumbar vertebra.

Left common iliac vein. The common iliac veins are formed opposite the sacro-iliac articulation by confluence of the external iliac and

hypogastric veins. They converge as they ascend and unite opposite the upper border of the fifth lumbar vertebra and a little to the right of the midline to form the inferior vena cava (Jackson).

The left common iliac vein ascends more obliquely toward the right to cross the interiliac trigone. It passes over the left margin of the intervertebral disc between the fifth lumbar and first sacral vertebræ and over the fifth lumbar vertebra. The lower border of the left common iliac vein in the midline is 3.5 centimeters below the bifurcation of the aorta, and only 1 centimeter below the bifurcation of the aorta and only 1 centimeter above the upper border of the first sacral vertebra (Figs. 1 to 8).

The left common iliac vein must be guarded carefully during any operative procedure within the interiliac trigone. It crosses the upper part of the trigone and practically subdivides it into an upper and a lower segment. *The superior hypogastric nerves cross this vein enmeshed in connective tissue.* Extreme gentleness is required in stripping the left common iliac vein of connective tissue and nerves because of its friable walls. It is best to start the dissection at the promontory, where the nerves can be identified and elevated with a blunt hook. Then the nerves and connective tissue can be dissected upward.

Ureters. The ureters enter the inferior angles of the interiliac trigone. They cross the brim of the pelvis on either side at the level of the division of the common iliac artery into the external iliac and hypogastric arteries. They descend along the lateral walls of the pelvis in front of the hypogastric artery (Fig. 10).

The right ureter is the one most likely to be seen within the operative zone (Fig. 12). This ureter crosses the right common iliac artery at the level of the lower border of the first sacral vertebra 3.5 centimeters from the midline. Its position corresponds to the point of bifurcation of the common iliac artery into the external iliac and hypogastric arteries. The ureter is bound to the posterior layer of the peritoneum by connective tissue, but it is easily dissected away. Adhesion of the ureter to the posterior surface of peritoneum serves to differentiate that structure from the nerves and vessels in the interiliac trigone. The

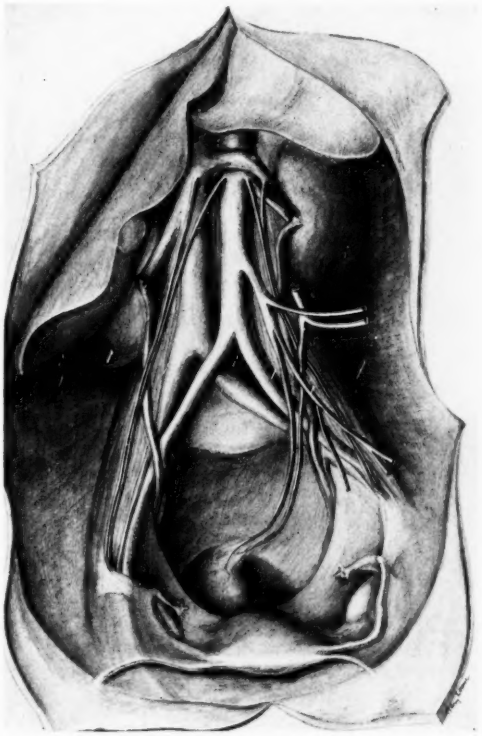

Fig. 10. Dissection to show the relation of the ureters to the interiliac trigone.

nerves and vessels are intimately bound to the retroperitoneal connective tissue, but are not adherent to the posterior surface of the peritoneum.

The left ureter is hidden from view. As the peritoneum is dissected toward the left, the inferior mesenteric artery may be seen running through the root of the mesocolon. The ureter is completely covered by the lower part of the inferior mesenteric artery and its branches, the sigmoid and superior hemorrhoidal arteries (Figs. 10, 12).

A. A. Davis, in a series of 12 operative cases, reports having seen an accessory ureter running in the midline on 3 occasions, closely simulating a single large presacral nerve. In the present study no such anomaly was encountered. In the infants, however, the right ureter often bent sharply toward the midline,

Fig. 11. Vertical incision made through the posterior parietal peritoneum extending upward from the promontory to expose the interiliac trigone. Note the long pelvic mesocolon.

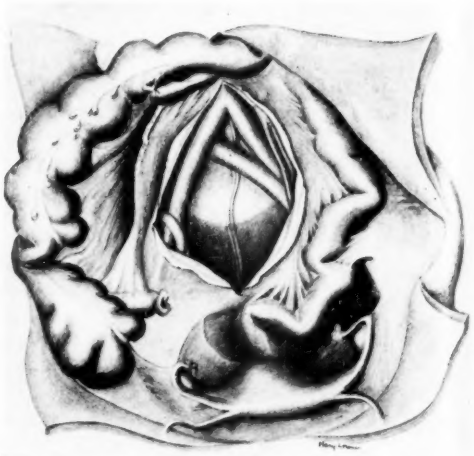

Fig. 12. The peritoneal flaps have been dissected laterally to expose the interiliac trigone. Note the short pelvic mesocolon in this case.

where it could be seen through the thin layer of peritoneum.

Sigmoid and mesocolon. Most frequently the sigmoid is found in the left side of the pelvis lateral to the interiliac trigone. However, it is not unusual to find the sigmoid displaced to the right side of the pelvis or over the interiliac trigone. Variations in the location of the colon are dependent on the length and manner of attachment of the mesocolon.

In most cases the mesocolon is short, providing the sigmoid with limited mobility and allowing it to remain in the left side of the pelvis (Fig. 12). In 11 of the 23 adult dissections, the mesocolon was prolonged to as much as 8 to 10 centimeters (Fig. 11). In these cases the sigmoid was found over the promontory of the sacrum covering the interiliac trigone, or in the right iliac region. The mesocolon covered the posterior parietal peritoneum overlying the interiliac trigone. The sigmoid and mesocolon were easily displaced to the left allowing proper exposure of the interiliac trigone.

In one infant dissection (1 per cent) the mesocolon had a midline attachment. The two folds of peritoneum forming the mesocolon, covered the interiliac trigone at the level of the lower lumbar vertebræ and promontory. Roussel found this abnormality in 15 per cent of his cases; Elaut in 8 per cent; and Cotte in 1 per cent. Bernard found this type of attachment in 1 case only.

Operative exposure of the interiliac trigone becomes more difficult in these cases, because the superior hypogastric nerves can be reached only by dissection through the layers of the mesocolon. When this difficulty is encountered it is necessary to incise both layers of the mesocolon to expose the peritoneum covering the superior hypogastric plexus. The mesocolon should be incised parallel with its root and one and one-half centimeters from it to avoid the superior hemorrhoidal artery (Elaut).

TECHNIQUE OF OPERATIVE RESECTION OF THE SUPERIOR HYPOGASTRIC PLEXUS

In resection of the superior hypogastric plexus adequate exposure is essential. The patient must be completely relaxed by means of a suitable anesthetic and must be placed in the Trendelenburg position. The abdomen is best opened through a right rectus suprapubic incision, extending above the umbilicus. Since dissection of the nerves must be carried from

the promontory of the sacrum upward over the lower lumbar vertebræ, proper exposure of this field will not be obtained unless the upper angle of the incision is extended. In some cases, if the distance between symphysis and umbilicus is reduced, it is better to make the abdominal incision to the right of the midline, starting midway between the pubis and umbilicus and ending midway between the umbilicus and xiphoid. It is essential that the sacral promontory be freely exposed without interference from upper angle of incision.

The small intestines are packed out of the way, and the sigmoid is displaced to the left to expose the peritoneum overlying the lower lumbar vertebræ. A vertical incision is then made through the posterior parietal peritoneum, extending from the promontory upward to the bifurcation of the aorta (Fig. 11). With a blunt edged curved scissors (Ferguson scissors are well suited) the peritoneal flaps are freed from the underlying connective tissue, and reflected laterally as far as the common iliac arteries. This exposes the interiliac trigone (Fig. 12). Portions of the nerves composing the superior hypogastric plexus may be seen embedded in the connective tissue. By blunt dissection the nerve fibers can be identified clearly, and elevated by passing a blunt instrument behind them. As the plexus is put on the stretch, blunt dissection discloses the triangular shape of the plexus, and the inferior hypogastric nerves are to be seen running beneath the peritoneum toward the lateral rectal spaces. A wide portion of the plexus may be excised without ligature. Any bleeding which may occur is due to severing of the vasa vasorum and is controlled readily by pressure. Below the fourth lumbar vertebra there are no vessels of importance. The middle sacral vessels are situated here, embedded in connective tissue overlying the vertebræ.

If a central compact plexus is not easily identified, two bilateral nerve trunks may be present. In these cases it is probably best to remove the entire subperitoneal connective tissue layer, extending from the promontory upward to the aortic bifurcation and laterally to the common iliac arteries. This assures the practicability of thorough resection of all nerve fibers. At times the operator may identify one single band of nerves and neglect to look for a second nerve trunk. Because of the possibility of bilateral parallel nerves one should never be satisfied with isolation of a single nerve until the existence of a mate is eliminated.

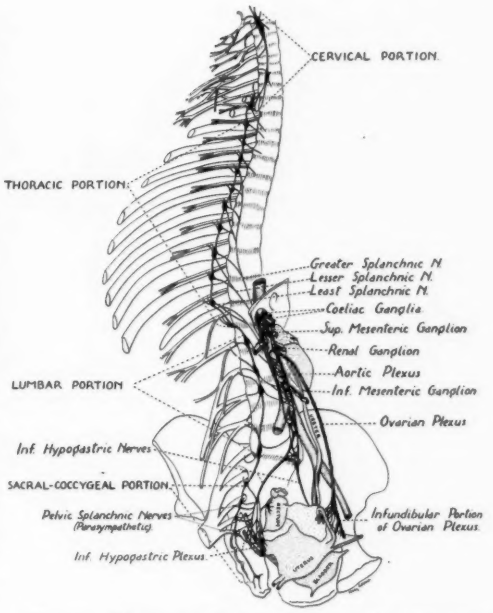

Fig. 13. Diagrammatic sketch to show the abdominal and pelvic sympathetic plexuses and their communications with the main sympathetic trunk as well as with the pelvic nerve. Spinal nerves, white; sympathetic nerves, black; parasympathetics, gray.

CONCLUSIONS

1. Seventy-five dissections were done in order to study the anatomy of the superior hypogastric plexus.

2. A plexus was found in 84 per cent, a single nerve in 8 per cent, and parallel nerve trunks in 8 per cent.

3. The superior hypogastric plexus always traverses the interiliac trigone. This is the space formed below the bifurcation of the aorta, bounded laterally by the common iliac arteries, and limited inferiorly by the promontory of the sacrum.

4. The left common iliac vein, the middle sacral vessels, and the right ureter are found within the trigone.

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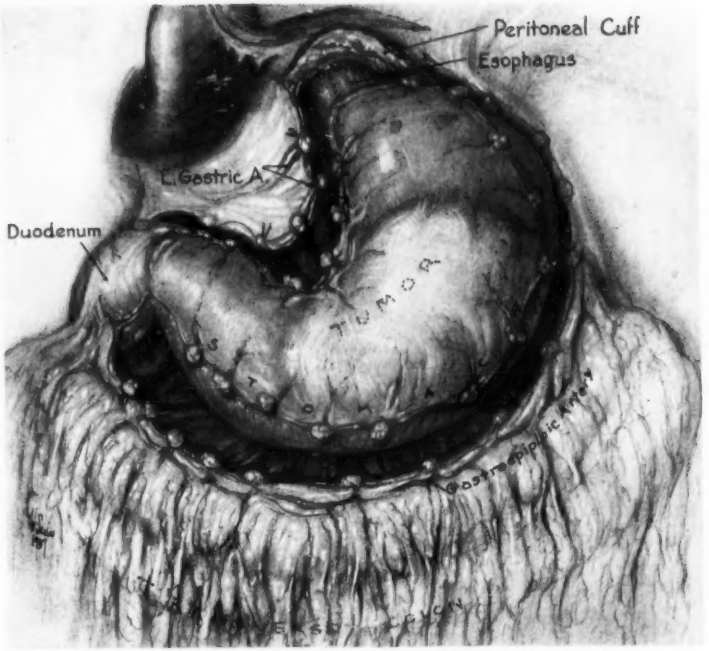

Fig. 1. Through a left rectus incision the upper end of the stomach is exposed. The left lobe of the liver is detached from the diaphragm by severing the avascular ligament which fixes it to that structure. The left lobe of the liver is then pulled to the right, exposing the point where the esophagus penetrates the diaphragm. The peritoneal flap which is later to be attached to the jejunum below at the point of anastomosis, as shown in Figures 4, 5, and 6, is now fashioned. The posterior flap is to be fashioned after the stomach has been completely detached.

Fig. 2. All of the blood supply of the stomach along the greater and lesser curvature has been ligated. The peritoneal cuff over the esophagus, as shown in Figure 1, has now been turned upward. The lower end of the stomach is now ready to be severed by transection through the duodenum.

Complete Removal of the Stomach for Malignancy; with a Report of Five Surgically Successful Cases.—Frank H. Lahey.

CLINICAL SURGERY

FROM THE DEPARTMENT OF SURGERY, THE LAHEY CLINIC

COMPLETE REMOVAL OF THE STOMACH FOR MALIGNANCY

With a Report of Five Surgically Successful Cases

FRANK H. LAHEY, M.D., F.A.C.S., Boston, Massachusetts

IN a discussion of total gastrectomy for malignant lesions of the stomach with anastomosis of the jejunum to the esophagus, it seems proper to state at once that the number of cases in which the operation can be employed is, quite naturally, limited; that since the operation is to be considered only in those cases in which a large part of the stomach is involved, extragastric metastases, even though they are not visible, and the operation is not justifiable if they are visible, are present in practically all of the cases. It is possible, however, if the malignant lesion in the stomach is a leiomyosarcoma, as in Case 5 here reported, that at least the idea of possibility of a cure may be entertained. In those cases in which the malignant lesion in the stomach is carcinoma, one cannot reasonably expect to be able to accomplish anything more than a prolongation of life but that with reasonable digestive comfort. In the reported 5 cases in which treatment was surgically successful, 1 patient, who had a carcinoma involving practically the entire stomach, lived 3½ years and earned her living during nearly all of that period; 1 has lived now a little more than a year and does not have any evidence of recurrence; 1 (leiomyosarcoma) has been operated upon too recently to be worth considering from the viewpoint of prolonged life; 1 patient died in 6 months, and 1 died 9 months after operation. The latter 2 patients could hardly be considered as having had their lives prolonged or demise made very much more comfortable. It seems wise to present the above facts clearly lest overenthusiasm on our part or others result from a report on this subject.

It is but fair, on the other hand, to say that the woman who has now lived a year without evidence of recurrence has obtained real and worth while prolongation of life without disturbing digestive difficulties, with the ability to carry on a great many activities and that without this procedure she would now either be dead or in a most distressing stage of carcinomatous involvement. In consideration of the patient who lived 3½ years, certainly 2 to 2½ years of this period was pure gain to her, based upon her expectation of life without this operation, and during these years she had no real difficulties in her digestive comfort and was able to carry on her usual activities. The woman with a leiomyosarcoma of the stomach, who has recently left the clinic after a successful total gastrectomy was performed, is at least relieved of the repeated massive gastric hemorrhages from the ulcerating sarcoma for which she entered the clinic, and has, in addition, the very definite possibility of prolongation of life and possible cure.

It may conservatively be stated we believe from our experience with total gastrectomy that this operation will be justifiable in occasional cases after exposure of the lesion, determination of its extent, and the absence of visual metastasis.

Because of the fact that leiomyosarcomas involving the stomach remain localized, without glandular metastasis, over long periods of time and because they are of a lower grade of malignancy than are carcinomas of the stomach, total gastrectomy may well be employed here even, as was the case in this patient, with practically all of the stomach involved. The risk of operation in the hands of those who have had experience with this procedure is now not prohibitive, the prospect of prolongation of life is great, and, should recurrence quickly take place, the end is not made any more distressing than would be the case if the operation had not been undertaken.

There are two distinct types of carcinomatous involvement of the stomach. In one, the more

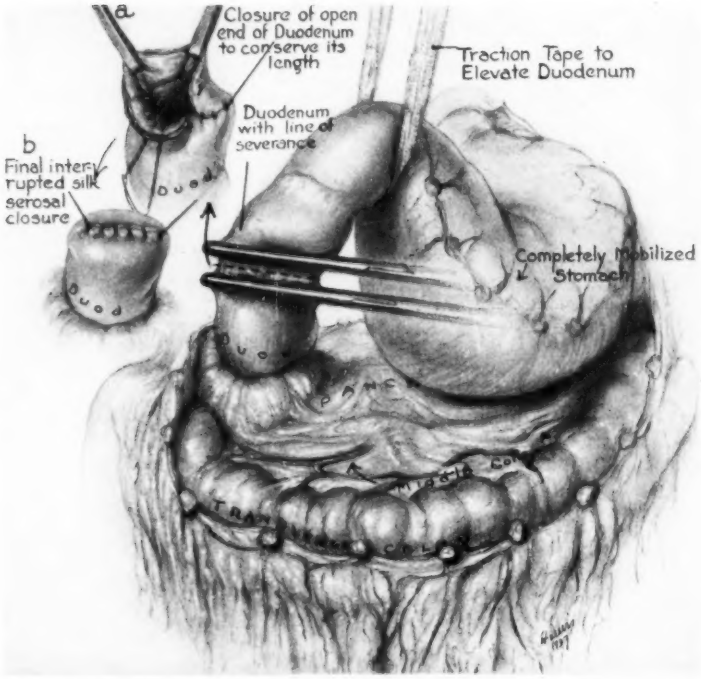
a
Closure of open end of Duodenum to conserve its length
Traction Tape to Elevate Duodenum
Duodenum with line of severance
b
Final interrupted silk serosal closure
Completely Mobilized Stomach

Fig. 3. The stomach and duodenum are completely mobilized, the duodenum grasped between clamps and to be cut across with a cautery at the dotted line. Inserts a and b show the method employed in closing the duodenum. In a, the clamp has been removed from the duodenum and the duodenum has been inverted with its end open and sucked out. This leaves sufficient duodenum to invert it easily (note the traction tape which elevates the duodenum out of its bed to make its exposure more satisfactory). Insert b, the final closure of the duodenum with interrupted silk seromuscular sutures.

common type, the malignant lesion is local, on the greater or lesser curvature or in the prepyloric region, with early and extensive metastatic involvement of the adjacent lymph nodes. It is this type of carcinoma of the stomach which we are so likely to see late in its course and in which the end-results in terms of percentage of cures are so discouraging. In the other, the type in which we are interested in this discussion, the lesion is not local but one in which the energy of the malignant growth appears to have expended itself in infiltrating throughout the walls of the stomach without apparent metastatic involvement of the adjacent lymph nodes. On microscopic examination of the stomach wall from such a case, as shown in the photomicrographic illustrations, the cancer cells appear to be streaming down between the muscle bundles of the stomach to form the linitis plastica or leather-bottle type of stomach. It is in this type of extensive carcinomatous involvement of all or nearly all of the stomach without apparent metastasis that total gastrectomy is well worth considering.

Although the operability of the malignant lesion of the stomach cannot with any degree of certainty be determined before operation either from the history or roentgenologic evidence, there are certain points which suggest that an exploration is justifiable to determine the possibility of total gastrectomy. In those patients who by roentgenologic evidence and chemical findings of the gastric contents, obviously have extensive carcinoma of the stomach but in whom evidence of secondary effects such as cachexia, fixation of the mass and palpable metastasis are not present and in whom roentgenograms (roentgenologic

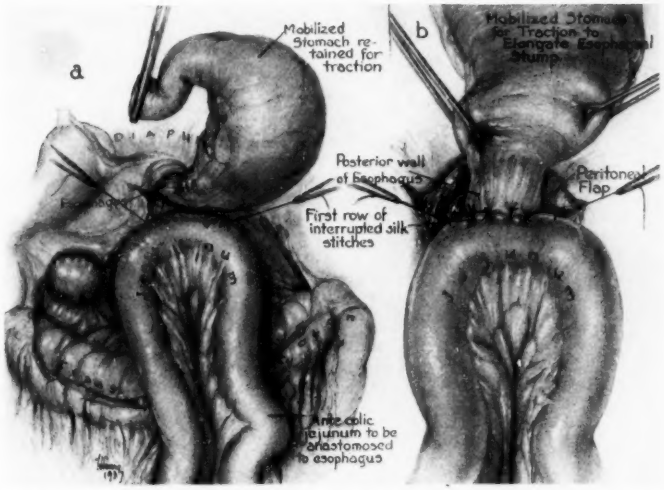
a
Mobilized Stomach retained for traction
Posterior wall of Esophagus
First row of interrupted silk stitches
Ante colic jejunum to be anastomosed to esophagus
b
Mobilized Stomach for Traction to Elongate Esophageal Stump
Peritoneal Flap

Fig. 4. a, The duodenum has been cut across. The stomach has been turned up and retained for traction. For the purposes of illustration, in a and b, the stomach is not shown wrapped in gauze to protect the wound edges from contamination with cancer cells. Note in inserts a and b that the esophagus is freed from the diaphragm for a considerable distance and so pulled down that direct approximation of the jejunum to it is made easier. In a, a long loop of jejunum has been brought up in front of the transverse colon and is to be approximated at the dotted line, marked by arrows, to the esophagus. In b, the posterior row of black silk stitches between the esophagus and the jejunum has been inserted.

illustrations) demonstrate a rigid walled stomach without peristaltic waves, through which barium quickly passes, exploration as to the possibility of performing total gastrectomy is distinctly justifiable.

Total gastrectomy in our first 2 patients resulted in fatalities because these patients were not well selected, both having too far advanced lesions. Failure in these cases, however, was largely attributable to our lack of knowledge and experience concerning the technical management of these cases. An attempt was made in one to employ a stomach clamp on the stump of the esophagus, an almost impossible procedure at least for us and one that distinctly hampered the security of the suture line, and in the other the esophagus was cut completely across and, with its end open, a direct anastomosis was made between the open end of the esophagus and the side of the jejunum. This resulted in spilling of infected esophageal contents which undoubtedly played a part in the fatality by the production of peritonitis. Total gastrectomy was then performed successfully in 3 cases. Another fatality resulted from the unwise application of the operation to a patient in whom the disease was too far advanced, and successful total gastrectomy was then done in 3 cases with no fatalities, making attempted total gastrectomy in 8 cases, with fatalities in 3 cases, and success surgically in 5 cases.

From this experience much has been learned in the technical management of this operation, and a description of the operation of total gastrectomy as it is now employed, together with the steps which have been developed in this clinic to add to its safety is here presented.

The operation is now done with the patient under high spinal anesthesia, nupercaine, 1:1500, being used. This type of spinal anesthesia, with the use of 8 to 20 cubic centimeters, can be trusted to last at least 3 hours and thus allows plenty of time for the completion of the operation, with the abdominal wall completely relaxed and with a satisfactory and adequate exposure. I feel sure that this anesthetic has greatly facilitated and added to the safety of the operation particularly in regard to its technical steps, and, in addition, has resulted in lessened drops in blood pressure and a lessened degree of shock to these patients. I believe that the 3 deaths in this series are at least in some part attributable to the inadequateness of the spinal anesthetic as given then, in

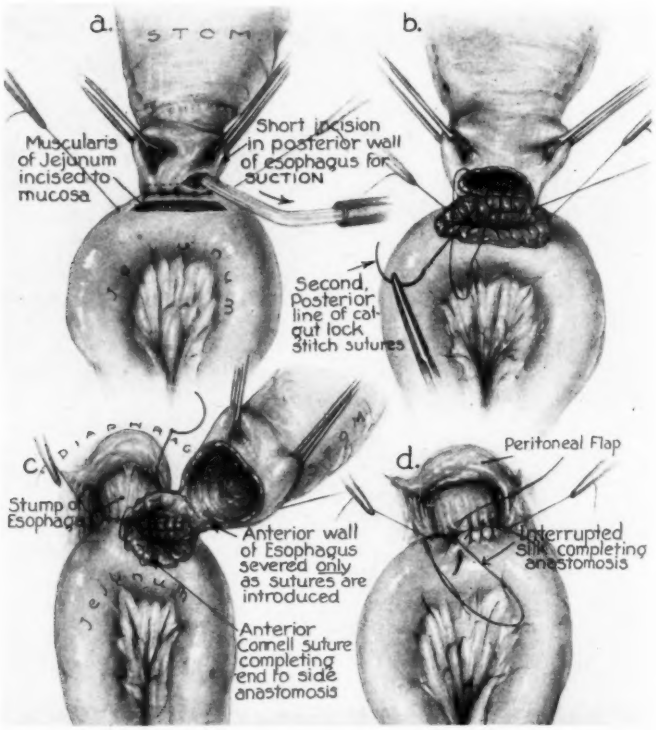
a.
STOM
Muscularis of Jejunum incised to mucosa
Short incision in posterior wall of esophagus for SUCTION
b.
Second, Posterior line of cat-gut lock stitch sutures
c.
Stump of Esophagus
Anterior wall of Esophagus severed only as sutures are introduced
Anterior Connell suture completing end to side anastomosis
d.
Peritoneal Flap
Interrupted Silk completing anastomosis

Fig. 5. a, The posterior row of sutures between the jejunum and the esophagus has been inserted. The jejunum has been incised to the mucosa and the dotted line indicates where the esophagus is to be incised. The esophagus is incised for a small distance at its left side, but only of sufficient length to permit the introduction of a suction tube. The stomach and esophagus are carefully sucked out to prevent soiling from the contents. In b, the jejunum is incised through its mucosa and the posterior row of lock stitches of catgut put in between the esophagus and the jejunum. As stated in the text, the posterior wall of the esophagus is incised only as the lock stitches are applied. In c, the anterior row of catgut sutures is applied by the Connell method of in, out, and over sutures and the esophagus is cut away either completely or as the stitches are inserted. In d, the anastomosis is now completed, with interrupted silk sutures inserted between the esophagus and the jejunum. Notice the peritoneal flap which is to be sutured to the jejunum to take the weight off the suture line.

terms of its limited time period, to the fact that when the patient came out of the novocain spinal anesthesia which was then given, a deep general anesthetic had to be administered which resulted in unsatisfactory exposure and produced advanced degrees of shock.

It is of interest as far as the anesthesia goes to record that following unsatisfactory experiences with novocain spinal anesthesia with its limited length of time of relaxation, Cases 1, 2, and 3, performed before the development of dilute nupercaine spinal anesthesia were successfully accomplished under intratracheal cyclopropane anesthesia, combined with regional infiltration with novocain and splanchnic block, with satisfactory relaxation and exposure.

All of these operations have been done through long left rectus incisions; additional cross incisions or incisions involving resection of ribs have not been necessary.

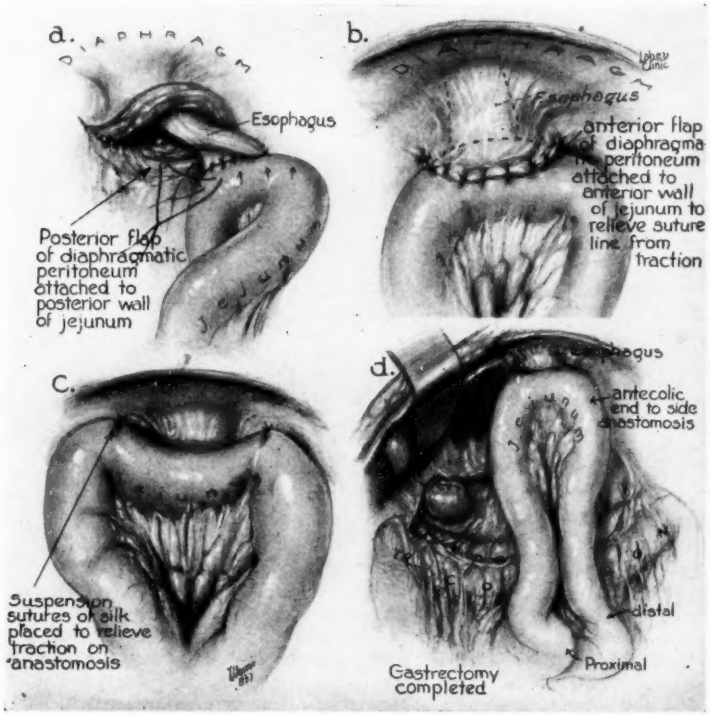
a.
Esophagus
Posterior flap of diaphragmatic peritoneum attached to posterior wall of jejunum
b.
Esophagus
anterior flap of diaphragmatic peritoneum attached to anterior wall of jejunum to relieve suture line from traction
c.
Suspension sutures of silk placed to relieve traction on anastomosis
d.
antecolic end to side anastomosis
distal
Proximal
Gastrectomy completed

Fig. 6. With the anastomosis between the end of the esophagus and the side of the jejunum now completed, the posterior flap of peritoneum fashioned from the diaphragm is sutured to the jejunum for its support and to remove the weight of the antecolic jejunum from the line of anastomosis. In b, the anterior flap of diaphragmatic peritoneum is now attached to the anterior wall of the jejunum, likewise, to relieve the suture line from the weight and traction of the loops of jejunum. In c, the jejunum has been suspended to the diaphragm by sutures of silk to relieve traction on the angles of the anastomosis, as was done in the last case. In d, the operation is completed. Note the long proximal antecolic loop of jejunum, note the absence of any entero-enterostomy. It is the long proximal loop which is to serve as a substitute for a stomach in these cases in which all of the stomach has been removed. Were entero-enterostomy done, this proximal loop immediately would drain and would not then serve as a substitute for the stomach.

After the abdomen is opened, the avascular attachment of the left lobe of the liver to the diaphragm is severed with scissors (Fig. 1) and the left lobe of the liver is folded to the right with a gauze pad over it and held in this position with a long bladed retractor. This maneuver, proposed by George Gray Turner and others, provides adequate exposure of the left half of the diaphragm and the point at which the esophagus passes through that structure. The gastrocolic attachments to the greater curvature are then ligated from the duodenum up to the point where the greater curvature joins the esophagus. A warning should be stated here as to the danger of injury to the splenic veins as they enter the hilum of the spleen when the vessels running to the greater curvature are ligated (Fig. 2.) This structure overlies the hilum of the spleen and at this point injury to splenic veins causes troublesome bleeding which is very difficult to control without doing a complete splenectomy.

The vessels of the lesser curvature are next controlled and the gastric vessels ligated high beside the point at which the esophagus penetrates the

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 7. Case 1. Barium roentgenogram before operation, showing almost complete involvement of the stomach by carcinoma.

Fig. 8. Case 1. Barium roentgenogram after total gastrectomy and anastomosis of jejunum to esophagus. Note dilated jejunal loop serving as a substitute for the stomach.

Fig. 9. Case 1. Photomicrograph of a section of the carcinomatous infiltration of the wall of the linitis plastica type of malignancy.

diaphragm. The wound edges are now draped, in order to protect them from soiling, with the cellophane pads which I have devised. The duodenum is then cut across and its open end carefully inverted with catgut and reinforced with mattress sutures of silk (Fig. 3).

The stomach is now turned up. One of the most important points which we have learned as the result of our experience with this operation is the need of retaining the entire stomach hanging by the esophagus as that structure passes through the diaphragm. The entire stomach is wrapped in a gauze pad to prevent contact of its carcinoma-filled walls with the operator's hands and with the surrounding tissue. With the stomach used as a handle, traction can be made so that flaps of diaphragmatic peritoneum can be cut posteriorly and anteriorly (Figs. 4, 5, and 6) where the peritoneum is reflected from the diaphragm over the esophagus to be utilized as will be described later to suture to the jejunum below the line of anastomosis, thus taking the weight of the attached jejunum and its mesentery off the line of anastomosis. This, also, is one of the most important technical points which we have developed, since if this is not done the anastomosed jejunum brought up over the transverse colon as an antecolic anastomosis hangs by its own weight, together with its mesentery and supported transverse colon, entirely upon the suture line of the anastomosis, and ascends and descends with diaphragmatic motion unless preliminary crushing of the phrenic nerve has been done. It is, I believe, undesirable to crush the phrenic nerve since this adds to the danger of pulmonary complications in an operative procedure in which this danger is already present to a high degree. The method of cutting posterior and anterior peritoneal flaps from the diaphragm and esophagus and then attaching these flaps with interrupted silk sutures to the wall of the jejunum below the line of anastomosis, relieving thus the anastomotic suture of all strain, is, I believe, an important factor in diminishing the risk of separation of the jejunum from its attachment to the esophagus, a structure at this point without peritoneal covering and of such consistency that it will not hold sutures well.

After the peritoneal flaps have been dissected free and fashioned into flaps for later attachment to the jejunum (Figs. 4, 5, and 6), traction is made upon the stomach. With gauze on the finger or in a long right angle cystic duct clamp, the cellular tissue about the esophagus is wiped upward until 2 to 3 inches of the intrapleural portion of the esophagus are drawn down, care being used not to open its attached pleura. By this plan enough esophagus can be pulled down out of the thorax so that the point at which the anastomosis is to be made between the end of the esophagus and the side of the jejunum is much nearer the level of the abdominal wall and thus this anastomosis can be performed much more easily and with greater safety.

Fig. 10.

Fig. 10. Case 2. Barium roentgenogram before operation, showing extent of involvement of the stomach by carcinoma.

Fig. 12.

Fig. 12. Case 2. Linitis plastica type of carcinoma.

Fig. 13.

Fig. 13. Case 2. Barium roentgenogram after operation, showing the anastomosis between the esophagus and the jejunum and the dilated jejunum serving as a receptacle for food.

After the region below the esophagus is carefully protected with gauze pads as a precaution against possible contamination during the anastomosis, a long loop of jejunum, one that can readily be approximated to the esophagus, is now brought up over the transverse colon and attached by interrupted silk sutures to the posterior wall of the turned-up esophagus with its stomach still attached. Here it is important to speak of a point which we have learned as the result of our experience; that is, that one interrupted black silk approximation should be placed at each end of the posterior line of sutures first and that these sutures with their ends cut long and held in hemostats should be pulled apart and kept pulled apart while this posterior row of interrupted silk approximation stitch is being placed, thus insuring sufficient caliber to the anastomotic opening between the esophagus and the jejunum. Failure to appreciate the danger of making this opening too small made it necessary in one of our cases in which the patient is now living to institute postoperative dilatation because of suture narrowing.

With the posterior row of silk sutures inserted, an incision is made in the jejunum of a length to correspond to the width of the esophagus with the two traction sutures pulled apart. In none of the latter 5 cases in which the surgical outcome was successful were intestinal clamps employed either upon the esophagus or upon the jejunum. A very small incision is now made into the esophagus at one end and into this is quickly introduced a rubber catheter attached to a suction apparatus and all of the contents of the esophagus are carefully sucked out. When this has been accomplished, the incision in the esophagus is extended a short distance and a second row of continuous sutures of catgut is applied between the posterior cut edge of the jejunum and the posterior edge of the esophagus as far as it is cut, care being taken to lock such stitches to control oozing from the cut edges but also to prevent shortening of the suture line, which would result in narrowing of the lumen. As the cut portion of the esophagus is approximated to the cut edge of the jejunum, a little more esophagus is cut across and sutured to the jejunum until the entire posterior second layer of locked catgut sutures is inserted. With a double posterior row of sutures now inserted, there is no danger of the esophagus slipping upward and the anterior wall of the esophagus is

Fig. 11. Case 2. Gross specimen.

Fig. 14.

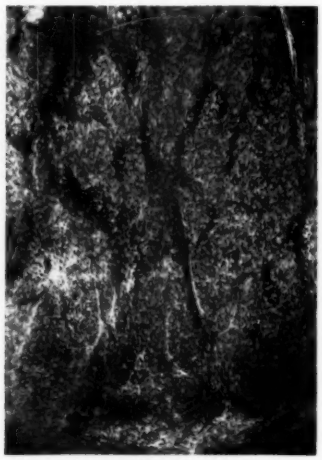

Fig. 16.

Fig. 17.

Fig. 14. Case 3. Barium roentgenogram before operation, showing the extent of involvement of the stomach by carcinoma.

Fig. 16. Case 3. Photomicrograph of section showing linitis plastica type of infiltration of the gastric wall.

Fig. 17. Case 3. Barium roentgenogram after operation, showing dilated loop of jejunum serving as a substitute for a stomach.

entirely severed, thus completely detaching the stomach from the esophagus. The posterior row of catgut sutures is now continued as a Connell suture, as in gastro-enterostomy, onto the anterior wall, and the anterior wall of the esophagus is united to the anterior wall of the jejunum, care being taken at all times to make traction upon the two original silk guy stitches in an outward direction in order to maintain the caliber of the anastomotic opening between the esophagus and jejunum. An anterior row of interrupted silk sutures is now inserted, and with the anastomosis completed, the prepared posterior apron of peritoneum is attached to the jejunum below the line of anastomosis by interrupted silk stitches and the anterior peritoneal flap is attached in the same way to the jejunum below the line of suture. This, as already stated, is a most important step in making the operation safer, since it removes all weight and tension from the suture line. No entero-enterostomy between the two loops of the anastomosed jejunum is done.

Fig. 15. Case 3. Gross specimen.

Many of the visitors to the clinic who have witnessed these operations of total gastrectomy and many others who have seen the illustrations of this technical procedure in our exhibits at meetings have been a little shocked at the fact that jejunojejunostomy is not performed in these cases and have asked us if we have not had trouble with obstruction at the point of jejuno-esophageal anastomosis. I believe that to do jejunojejunostomy in these cases is a mistake. The danger is not that the jejunal contents will not pass along the jejunum but that, with inadequate caliber to the anastomosed esophagus, food will not pass from the esophagus into the jejunum.

We have attempted, by leaving a long proximal loop of jejunum attached to the esophagus, to make this loop at least in part serve as a substitute for a stomach. Illustrations taken after the ingestion of barium show a considerable accumulation of the barium meal in the proximal jejunal loop. We have had no trouble with these long proximal loops draining past the anastomosed esophagus and I believe it is a disadvantage to add jejunojejunostomy to the procedure.

Fig. 18. Case 4. Barium roentgenogram before operation, showing practically complete involvement of the stomach by carcinoma.

Following the completion of the anastomosis, the left lobe of the liver is returned to its normal position beneath the diaphragm but no attempt is made to suture it to the diaphragm from which it has been detached. The abdomen is then closed by whatever method one desires. In many of our cases the abdominal incisions have been closed following the total and subtotal gastrectomy with a single layer of catgut in the peritoneum; the remaining layers are closed by interrupted through and through mass sutures placed quite close to the wound edges and close together. Although we do not wish as yet definitely to advocate this method of closure of abdominal wounds after total and subtotal gastrectomy, one layer closure has definite advantages in saving of time and quite possible advantages in lessening wound complications.

Following operation, the feeding of these patients is turned over to the gastro-enterological section of the clinic, and their plan is here submitted. No food or fluid is given by mouth for 4 days, all administrations being given intravenously. On the fifth day after operation, small amounts of malted milk or strained cream of wheat gruel are given every hour. The usual initial feedings consist of ½ ounce and after a day or two this amount is increased to 1 ounce and later to 3 ounces. About the eighth day after operation, cream of wheat is given at 10:00 in the morning and a soft-cooked egg at 4:00 in the afternoon. If this is well tolerated, other feedings are added at intervals of approximately 2 hours, so that the patient is getting a small, soft feeding every 2 hours. He is encouraged to drink water in addition to these feedings, as often as he likes.

Fig. 19. Case 4. Gross specimen of the totally removed stomach. Note the linitis plastica type of carcinomatous infiltration of its walls. The defect on its anterior wall is the section removed for microscopic examination.

About the fourteenth or fifteenth day after operation, the patient is placed on a comparatively full diet, starting with five small meals daily. The soft, 2-hour feedings and the malted milk and gruel every hour are omitted. These small meals include cooked cereals, soft cooked eggs, cooked fruits, broiled bacon, chicken, fish, lamb or beef, baked potato or mashed potato, puréed vegetables and bland dessert. At the beginning of this new regimen, the patient is told that he need not eat all of his food on any one tray, but he is encouraged to eat as much as he can comfortably hold. By the time of his discharge from the hospital, he is usually eating all of the food on his trays and enjoying his meals. He is kept on a bland diet for several weeks after dismissal from the hospital. The first change that is made is in the frequency of the feedings.

After he can take three meals without any particular discomfort, he is allowed to have unstrained vegetables. If at any time he experiences discomfort, he is advised to return at once to a bland diet with frequent feedings, eliminating the solid foods for 2 or 3 days.

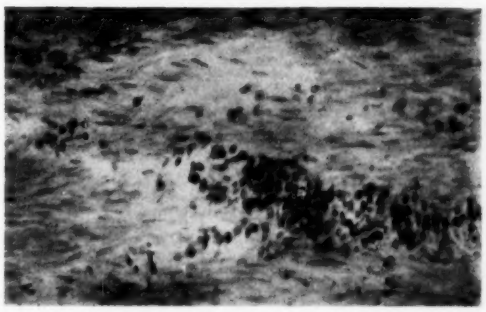

Fig. 20. Case 4. Photomicrograph of a section of the gastric wall.

Fig. 21.

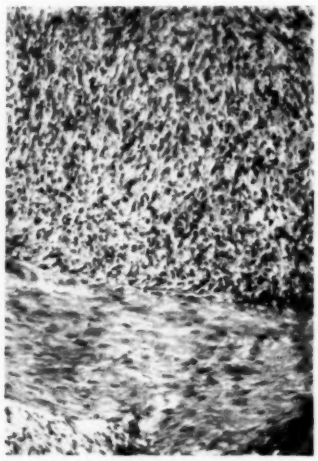

Fig. 23.

Fig. 24.

Fig. 21. Case 5. Barium roentgenogram showing the almost complete involvement of the stomach by large leiomyosarcomatous masses.

Fig. 23. Case 5. Photomicrograph of section showing typical leiomyosarcoma of the stomach.

Fig. 24. Case 5. Postoperative barium roentgenogram showing the anastomosis and loop of jejunum serving as a stomach.

As would be expected, rather severe grades of secondary anemia occur after operation owing to the lack of a stomach. Anemia in these cases has been satisfactorily controlled by the administration of liver, iron, and hydrochloric acid. The patient is instructed to take from 20 to 30 drops of dilute hydrochloric acid with each meal.

Fig. 22. Case 5. Gross specimen.

Vitamin concentrates in one form or another also are given. It is surprising how well these patients eat and how well their nutrition is maintained.

REPORT OF CASES

CASE 1. A woman, aged 36 years, came to the clinic August 29, 1929, because of nausea and gas and loss of appetite of 1½ years' duration. She had had severe pain in the epigastrium which was worse since she had the "grippe" in December, 1928. She had lost 20 pounds since November, 1928.

Examination at the clinic revealed that the erythrocytes numbered 4,140,000 and leucocytes 8,600; the hemoglobin was 85 per cent. On gastric analysis, the total acidity was 5; free hydrochloric acid, 0; blood, grade 2, was found. A roentgenologic diagnosis was made of a tumor of the greater curvature of the stomach (Fig. 7).

September 14, 1929, total gastrectomy, esophagojejunostomy and entero-enterostomy were performed. The pathologist's report was colloid carcinoma of the stomach, of the linitis plastica type, with metastasis to the lymph nodes (Figs. 8 and 9).

November 9, 1929, erythrocytes numbered 3,050,000 and the hemoglobin was 65 per cent. The patient was able to return to her former work and remained in comparatively good health for more than 3 years. She died January 7, 1933, of recurrence.

CASE 2. A woman, aged 64 years, came to the clinic May 15, 1933, because of "stomach trouble." She had had a sudden attack of epigastric pain 5 months previously and had vomited. Since that time actual pain had not been present but she had continued to have distress after meals, with regurgitation.

Examination at the clinic revealed that the erythrocytes numbered 4,510,000; the hemoglobin was 75 per cent. On gastric analysis, the free hydrochloric acid was 7 and total

acidity, 24; no blood was found. Roentgenologic examination revealed a carcinoma of the stomach (Fig. 10).

At operation, May 20, 1933, a carcinoma simplex of diffuse type was found which involved the entire stomach, and total gastrectomy was performed (Figs. 11, 12, and 13). After operation the erythrocytes numbered 4,160,000, and the hemoglobin was 80 per cent.

On roentgenologic examination, March 8, 1934, 10 months after operation, a new carcinoma was found in the transverse colon. The patient died September 23, 1934.

CASE 3. A woman, aged 57 years, came to the clinic December 20, 1933, because of severe pain after eating and loss of weight and strength. She had had vague indigestion for years. On August 15, 1933, she began to have severe distress. Her usual weight was 135 pounds; on admission it was 107 pounds.

Erythrocytes numbered 4,040,000, leucocytes, 7,850, and the hemoglobin was 74 per cent. Gastric analysis revealed total acidity, 9, and free hydrochloric acid, 5; blood, grade 4, was found. The pre-operative roentgenogram is shown in Figure 14.

At operation, January 2, 1934, a carcinoma simplex of the linitis plastica type was found and total gastrectomy performed (Figs. 15, 16, and 17). August 23, 1934, on examination elsewhere, evidence of recurrence was found. The patient died 9 months after operation.

CASE 4. A woman, aged 61 years, came to the clinic November 9, 1936, because of abdominal pain. She had lost 13 pounds. Gastric analysis revealed total acidity, 18, and free hydrochloric acid, 4; no blood was found. Erythrocytes numbered 3,320,000, leucocytes, 7,900, and the hemoglobin was 70 per cent. The pre-operative roentgenogram is shown in Figure 18.

Total gastrectomy was performed December 7, 1936, and a carcinoma of the linitis plastica type was found (Figs. 19 and 20). No glands were seen outside of the stomach or in the mesentery.

December 28, 1936, erythrocytes numbered 3,690,000 and leucocytes, 7,300; the hemoglobin was 74 per cent. A constriction of the esophagojejunal juncture was dilated February 25, 1937, and this procedure has been repeated at intervals. In February, 1937, when the patient returned for examination and dilatation, no evidence of recurrence was found. Her digestive processes are quite reasonably satisfactory, as is her general activity and state of health.

CASE 5. A woman, aged 27 years, came to the clinic October 8, 1937, because of sudden onset of massive gastric hemorrhages, without previous symptoms. Her appetite had been good and she had not had any digestive disturbances. Operation had been performed elsewhere in December, 1933, and several lesions which were thought to be benign had been removed from the stomach.

Examination at the clinic was negative except for her gastric condition. The erythrocytes numbered 3,460,000 and leucocytes, 6,600; the hemoglobin was 53 per cent. On roentgenologic examination, multiple new-growths, probably leiomyosarcomas, were found occupying practically the entire stomach (Fig. 21).

Total gastrectomy, with anastomosis of the jejunum to the esophagus, was performed October 18, 1937. The pathologist's report was leiomyosarcoma of the stomach (Figs. 22, 23, and 24). Examination of this patient in January, 1938, showed the hemoglobin to be 89 per cent; the erythrocytes numbered 5,800,000. Her weight had remained the same (90 pounds). At this time her general condition was quite satisfactory.

SUMMARY

Care must be exercised in the selection of patients to be submitted to total gastrectomy.

In the cases of carcinoma suitable for this operation, life may be prolonged but few if any cures may be expected. In cases of leiomyosarcoma, with early operation, it is not unreasonable to assume the possibility of a cure.

Technical procedures which we have developed as the result of our experience and which we believe make the operation easier and safer are submitted.

The successful cases are briefly reported, together with pre-operative and postoperative data. Total gastrectomy has now been successfully accomplished by a number of surgeons. It is a demonstrably justifiable procedure from the point of view of its technical performance and it may be done with a not excessive mortality. The ability of patients to exist in reasonable comfort without a stomach has been established.

NEPHROSTOMY

Some Clinical and Experimental Observations

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THE most satisfactory drainage of the kidney is obtained with a tube inserted into the pelvis through the renal parenchyma. Nephrostomy affords rapid relief of the renal infection usually associated with ureteral obstruction and gives better drainage than either pyelostomy or ureterostomy. Some surgeons employ nephrostomy routinely following all conservative operations on the kidney. A nephrostomy tube is frequently left in place following pyelotomy for stone, for the purpose of permitting better control of the associated renal infection; and some drainage through the lower pole of the kidney must always be had to make possible a succesful end-result following plastic operations on the renal pelvis.

Chronic pyelonephritis which responds to no other form of treatment may occasionally be relieved by nephrostomy, and thus the sequel of pyonephrosis and atrophic pyelonephritis may be prevented.

The patient who requires the removal of a pyonephrotic kidney but is too sick to withstand nephrectomy, can have a preliminary nephrostomy to tide him over until it is safe to remove the kidney. A large number of our patients belonged to this group.

Chronic unilateral or bilateral hydronephrosis due to low ureteral obstruction may be relieved temporarily by nephrostomy. Following this, an attempt can be made to free the ureter from the postoperative scar or adhesions secondary to chronic pelvic or adnexal inflammation.

Nephrostomy is indicated as a temporary measure following accidental ligation or cutting of the ureters in pelvic operations; particularly if the injury is bilateral. If the ureteral injury is diagnosed early enough—within the first 48 hours—and the condition of the patient permits; the abdomen should be reopened, and the ureteral damage repaired. This is not a simple task and usually requires the aid of the urologist with the cystoscope in the bladder, and ureteral catheters inserted, in order to locate the ureters. However, considerable time may elapse before a decision is made to relieve the patient of her anuria or the urinary extravasation, and she may then be too sick to withstand further abdominal exploration. It is here that nephrostomy done quickly and with a minimum of trauma acts as a life saving measure.

The technique commonly recommended for nephrostomy requires a muscle cutting lumbar exposure and delivery of the kidney. A small opening is then made in the pelvis, and a forceps inserted through this opening and brought out through the lower pole of the kidney. A small mushroom catheter is then carried back to the pelvis with the withdrawal of the forceps. However, nephrostomy is often necessary for sick patients who cannot tolerate the rather extensive operation of wide lumbar exposure and delivery of the kidney. Nephrostomy, just as cystostomy, should be a minor procedure; and it can be done equally as simply, and with very little discomfort to the patient.

During the past 4½ years we have done 28 nephrostomies successfully through a simple muscle splitting lumbar exposure of the lower pole of the kidney. Twenty-four of these were done under local infiltration anesthesia. In this operation, as shown in the accompanying illustrations (Figs. 1, 2, 3, 4), excellent exposure of the lower pole of the kidney is obtained in all cases. This is all that is necessary. The kidney is left *in situ* and is not delivered. A stab wound is then made in the lower pole through to the pelvis. This is followed by the insertion of an No. 18 or No. 20 catheter, preferably a mushroom, into the pelvis through this opening. Hemorrhage is readily controlled by the catheter in place. Hemostasis is aided by a small packing placed loosely around the tube. In 2 instances a superficial suture through the capsule on either side of the tube was necessary to control bleeding. The various steps of this operation are shown here. The incision is parallel to, and just below, the rib and about 6 inches long. The kidney rest need not be elevated high.

Exposure is simple and can be done in most cases under local infiltration anesthesia. Occasionally the peritoneum must be retracted forward gently, for the exposure at Petit's triangle

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may first bring the posterior edge of the peritoneum into view. Aside from the fact that the lumbar trigonum is the anatomical point for drainage of the kidney, the most important feature of having a tube come out at this point is that the patient can lie comfortably on her back without kinking or bending of the tube. This is most important in the postoperative care of these patients.

Thirteen of our patients had pyonephrosis or infected hydronephrosis, requiring nephrectomy, who were too sick to withstand any major procedure. Nephrostomy as a preliminary measure can be done very easily here with the technique as outlined.

The kidney is usually markedly enlarged, often adherent to the surrounding tissues, close to the transversalis muscle and fascia, and is usually well walled off by perinephritis. Muscle splitting exposure of the lower pole and a stab wound for drainage will usually suffice. Occasionally the infected kidney consists of 2 or 3 separate pyonephrotic sacs which do not communicate, and which must be incised and drained separately. Better exposure can readily be obtained by cutting the upper angle of Petit's triangle upward to the rib and with upward traction of the rib the rest of the kidney is brought into view. The exposure can also be aided by cutting the latissimus and internal oblique for about 1 inch, at the posterior angle of the incision—this, however, is usually not necessary.

Eight of the 13 patients requiring two-stage nephrectomies improved with preliminary drainage, so that the kidney could be removed successfully at a later date. The postoperative course following the second stage nephrectomy was uneventful in all cases. Five did not survive—they were very sick patients whose general condition was bad when first seen. Seven of the 13 had calculous pyonephrosis. In 4 of these a number of large stones were easily removed through this small incision under local infiltration anesthesia.

One patient had a stone in the renal pelvis which had produced an acute block with associated severe renal infection. Her gall-bladder had been removed 2 weeks previously under a mistaken diagnosis. When it was discovered later that her chills and fever were due to a renal calculus with infection, her condition had become grave. A simple nephrostomy was done very quickly under local anesthesia, and following this her condition improved rapidly. Three weeks later a recurrence of fever and chills made nephrectomy necessary. This was then done successfully, and with an uneventful postoperative convalescence.

One patient with a congenital solitary kidney had anuria of 4 days' duration. The x-ray findings had been negative for stone. A nephrostomy tube was inserted and brought about improvement for a few days, but his condition gradually became worse; he died 10 days after operation. Necropsy revealed a number of large stones that were radiotranslucent. At operation the kidney was under tension but showed no evidence of infection. Instead of the muscle splitting exposure it would have been best in this case to have made a wide exposure of the lumbar space and to have delivered the kidney. Careful exploration through a nephrotomy wound would have located the stones. These should have been removed at the time of operation. With stones left in the kidney, the presence of a tube may promote infection—or aggravate the already existent infection.

One patient had a badly infected kidney with apparently marked destructive changes, as shown by pyelogram. She was quite sick, and a nephrostomy was done at the time as a preliminary operation to a nephrectomy, which we planned to do later. She improved slowly at first, but after a period of 2 months, intravenous pyelograms showed a remarkable change. The kidney appeared almost normal. The tube was removed after a period of 3 months. Evidence of renal infection reappeared within a few days after this, and another nephrostomy was done. Another 2 months elapsed with a tube in the kidney, after which time the second tube was removed. She has been well since then. This patient has been seen frequently during the past 2 years. Her urine is still slightly cloudy, but she feels well. Repeated pyelograms appear normal, and her renal function on the side operated upon is good.

A frequent cause of chronic hydronephrosis, either unilateral or bilateral, is ureteral block due to extension from carcinoma of the uterus. These patients have already lost considerable weight and may be suburemic when this complication appears. Seven of our patients belonged in this group and were operated upon for temporary relief of the hydronephrosis. All operations were done very simply under local anesthesia. The general condition of these patients improved for only a short period of time or showed no change. No radical treatment of the carcinoma with either surgery or radiation was possible. All died within a period of 4 months.

One patient had hydronephrosis of one side with a constant dull ache in the loin which was due to postoperative pelvic adhesions, causing low ureteral obstruction. Repeated attempts at dilatation were unsuccessful and were usually

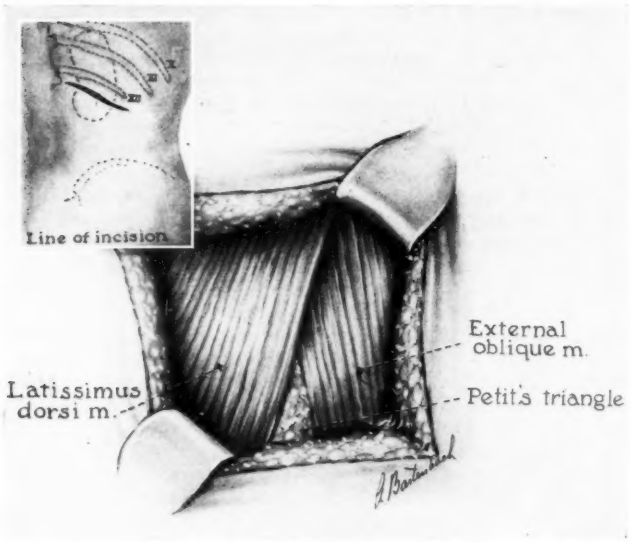
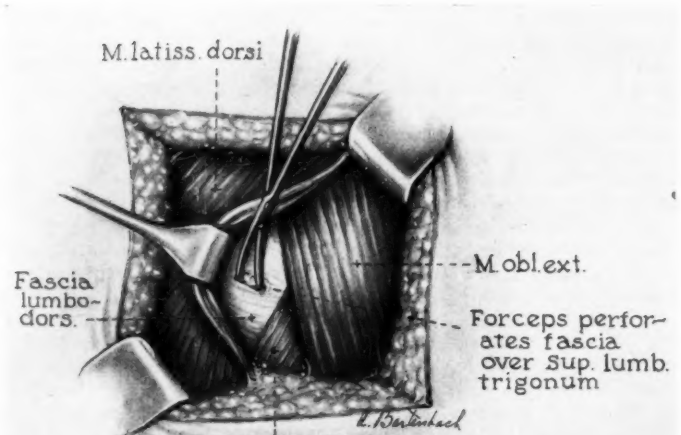


Fig. 1.

Figs. 1, 2, 3, and 4. Various steps of nephrostomy with a muscle splitting exposure of the lower pole of the kidney. The kidney is not delivered. This can be done under local infiltration anesthesia. Fig. 1. First step. Fig. 2. Muscle splitting operation. Fig. 3. Lower pole exposed and stab wound made, with kidney *in situ*. Fig. 4. Nephrostomy completed.



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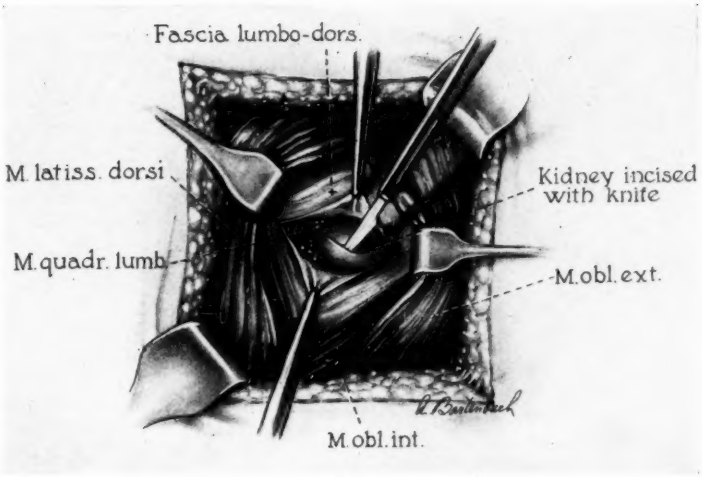

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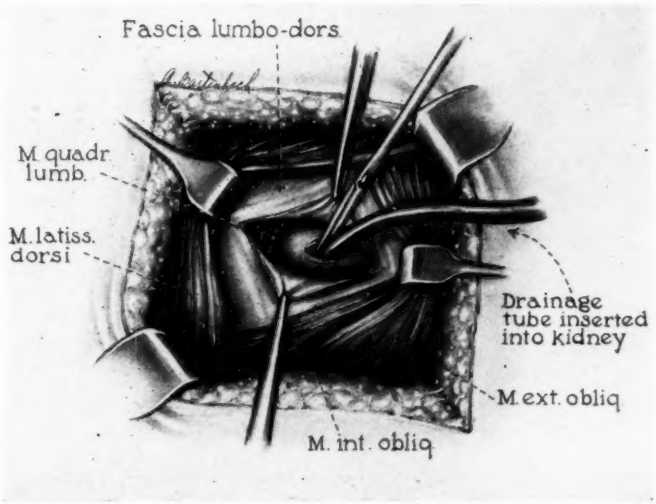

Fig. 4.

followed by fever of a few days' duration. Nephrostomy was then done. A few weeks later it was found possible to pass a small ureteral bougie after a rather prolonged session at the cystoscopic table, and with no postcystoscopic febrile reaction. This dilatation was then repeated at short intervals, and the nephrostomy tube was removed. When last seen there was no evidence of hydronephrosis, and she felt well.

Four patients had the ureters ligated or cut during pelvic operations. One patient was seen 9 days after operation. She had been passing some urine through the vagina, but she had a rather high fever and was uremic. She died the same day without operation. In another patient, seen 6 days after operation, a nephrostomy was done, but she expired 2 days later. Nephrostomy was done on one side only because the condition of the

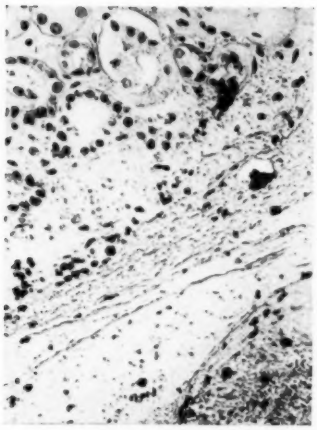

Fig. 5. Photomicrograph showing section of area in the kidney of a dog in which a nephrostomy tube had been left in place for 8 days and the kidney removed 3 months later. There is some fibrous tissue which had formed in a portion of the tract of the nephrostomy wound, but the rest of the kidney remained normal.

patient did not permit much surgery. It is possible that if seen earlier, a bilateral nephrostomy, which was indicated, could have carried the patient through.

One patient had anuria of 3 days' duration, but did not appear sick. Attempts at passing ureteral catheters were unsuccessful. The next day, however, some urine appeared in the bladder, and from then on she excreted large quantities of urine. The anuria was due probably to ligatures around both ureters which became loose after a few days, and the patency of the ureters was then restored. It would not be safe to wait a longer period before again operating in the hope that a happy end-result, such as this, would be the sequel.

Another patient had both ureters ligated. Four days later abdominal exploration was successful in partially deligating the left ureter, but the right ureter was torn in the attempt to remove the ligature. The torn ureter could not be sutured, but some of the defect was repaired by covering the posterior peritoneum over it. She was seen by us 7 days after the second operation, and 11 days following the first pelvic operation. She had been passing small quantities of urine from the bladder for 5 or 6 days. She was very sick, however, and her abdomen had gradually become markedly distended. The lumbar space was exposed under local anesthesia on the side where the ureter had been torn during the second operation. The peritoneum bulged somewhat into the wound, and it was opened before attacking the kidney. About 3000 cubic centimeters of urine escaped from the wound. Nephrostomy was then done, and the peritoneum was closed. This patient had a slow convalescence, but with it a progressive recovery. It is interesting to note the ability of the peritoneum to tolerate large quantities of urine for a long period after intraperitoneal rupture of the bladder and surgical injuries to the ureter.

We re-opened the abdomen 6 weeks later and attempted repair of the torn right ureter. Approach was very difficult because of adhesions and distortion of the ureter. It was found, however, that the defect in the ureter had been bridged over during this interval of diversion of the urine, apparently with the aid of the posterior peritoneum; and thus the continuity of the ureter was restored. This was a rather fortunate end-result, for late repair of ureteral injuries is often very difficult and may be unsuccessful. An attempt to repair a ureterovaginal fistula in another patient was unsuccessful because of a dense scar to which the iliac vessels were adherent. Nephrectomy of the involved side became necessary later.

We performed a number of nephrostomies on dogs, but were able in only 2 of our experiments to prevent the dog from pulling the tube out within the first 24 or 48 hours. The tube was removed 8 days after operation in both of the dogs we had been able to control, and the kidney then removed 4 weeks later in one, and 3 months later in the other. The wound in the kidney was difficult to locate 3 months after operation. Sections from this kidney show some scar on the surface, and some fibrosis in the tract of the nephrostomy (Fig. 5), but nowhere else. Except for this, the rest of the kidney is normal. It is evident, therefore, that very little injury to the kidney results from the nephrostomy. Considerable clinical evidence has demonstrated that the severely infected kidney frequently returns to normal following the relief of obstruction and drainage. This is particularly true following open drainage by nephrostomy and is evidenced within a few weeks after operation by a return to the normal pyelographic outline and normal renal function.

We did a large number of simple nephrotomies on dogs for the purpose of determining the best method of hemostasis following incision into the renal parenchyma. Complete hemostasis resulted following simple apposition and compression for a few minutes of the 2 halves of the nephrotomized kidney. This was reported some years ago by Carson and Goldstein.

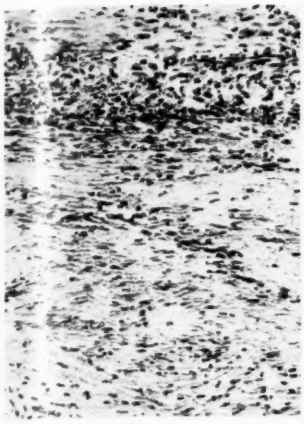

Fig. 6.

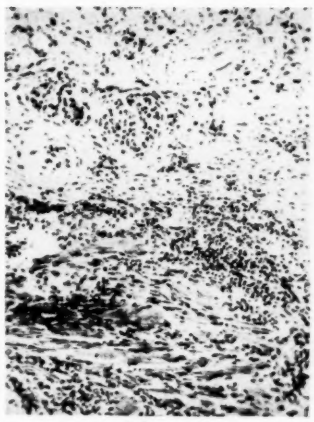

Fig. 7.

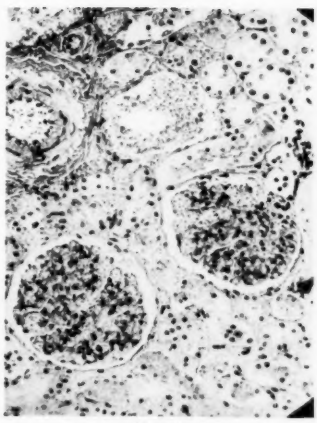

Fig. 8.

Figs. 6 and 7. Marked fibrosis and replacement of kidney tissue by scar 2 and 3 months following insertion of deep mattress sutures experimentally in the dog's kidney.

Fig. 8. The renal vein was clamped for a period of 15 minutes and the kidney removed 3 weeks later. Note degenerative changes still present.

A patient who had been stabbed in the loin developed profuse hematuria immediately afterward, but the urine had already begun to clear after a few hours. She continued to bleed, however, from the stab wound, and was operated upon. upon exposing the kidney we found that a clot had formed in the clean stab wound in the kidney, and complete hemostasis had resulted. The external bleeding was due to muscle injury which was readily controlled. We had here a clinical experiment showing that suture of the kidney is not necessary for hemostasis.

However, it would not be wise to depend merely on temporary compression of the nephrotomized kidney for permanent hemostasis. If the edges of the wound can be kept rather firmly together, excellent control of the bleeding can be had, and one can then feel quite sure of the hemostasis. We have found both clinically and experimentally that superficial sutures through the cut edges of the capsule running through the parenchyma on the surface, with or without the implantation of muscle or fat in the suture line, are all that is necessary to accomplish this purpose.

It is not necessary to employ deep mattress sutures. Deep sutures can do considerable harm. Constriction of the blood supply to the portion of the kidney incorporated in the mattress suture causes some necrosis from which bleeding may ensue. This is probably a major cause for late nephrotomy bleeding. It is not a rare experience to have a simple nephrotomy for a small stone followed by bleeding 2 weeks later which almost exsanguinates the patient. The late effect of necrosis and slough due to interference with the local blood supply of the area incorporated in the mattress suture is the formation of scar tissue. In the experimental animal, large areas of fibrosis in the center of the area incorporated in the mattress suture can be noted grossly when these kidneys are examined later. Much scarring and destruction ensues, as shown by the accompanying photomicrographs of sections of kidneys in which mattress sutures had been placed 2 (Fig. 6), and 3 (Fig. 7) months previously.

We have had occasion to re-operate upon 2 patients who had nephropexy 18 months previously in each case. The method of nephropexy consisted of carrying a No. 2 doubled chromic catgut suture through the lower pole of the kidney, and then firmly attaching it to the twelfth rib. The kidney was held firmly and well up in good position at the second operation 18 months later, but the lower pole showed considerable change grossly due to fibrosis. It is doubtful whether ligation of even a large aberrant vessel in the treatment of hydronephrosis—a procedure which is often controversial—can produce much more damage than noted in these 2 cases.

Temporary control of bleeding during the operation is usually obtained by compression of the kidney with one hand. In 2 cases in which we removed encysted cortical stones, the bleeding vessels which could be readily seen at the margin of the parenchyma and cyst wall were clamped and then ligated.

Various measures are recommended for temporary control of hemorrhage during nephrotomy, such as a rubber band, or a clamp about the pedicle. However, even temporary interference with the blood supply to the kidney may cause considerable cellular change which requires many weeks for regeneration.

Physiologists are well acquainted with the fact that compression of the venous circulation is most damaging to an organ, passive congestion interfering with oxidation and rapidly producing degenerative changes particularly as result of increased pressure and tension within the organ. Thus, clamping of the renal vein for 15 minutes caused degenerative changes from which the kidney had not entirely recovered 3 weeks later, as shown in Figure 8. Temporary clamping for 15 minutes of the entire pedicle, together with the ureter, is less damaging than clamping of the vein alone; and clamping of the renal artery alone is least damaging of these procedures.

These observations are not new. It is interesting to note that when the vein alone is clamped the kidney becomes blue, very tense and hard, and actually increases in size. When the artery alone is clamped the kidney becomes soft and pale and shrinks in size to almost one-half that of the normal kidney (2).

CONCLUSIONS

1. Nephrostomy can be done very simply through a muscle splitting lumbar exposure of the lower pole of the kidney. Local anesthesia will suffice in most cases.

2. Nephrostomy causes very little permanent injury to the kidney.

3. Deep mattress sutures should not be used for hemostasis in kidney surgery.

I am indebted to Dr. H. Necheles for his valuable aid and suggestions, to Dr. M. Appel for his aid in reviewing the histologic sections, and to Miss Garvin for her aid in preparing the microscopic sections.

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TIBIA AND FIBULA LENGTHENING BY THE TURNBUCKLE METHOD

F. A. ALCORN, M.D., Lincoln, Nebraska

SINCE November 8, 1932, there have been 37 bone lengthening operations done at the Nebraska Orthopedic Hospital, Lincoln, Nebraska. In 2 of these cases the femur as well as the tibia and fibula was lengthened. The lengthening was done 22 times on the left leg and 15 times on the right. All patients were under 17 years of age.

Thirty-two shortenings were from the results of poliomyelitis, 1 from fracture, 1 from cystic bone disease, 1 from tuberculosis of the hip, and 2 from a congenital anomaly.

Outside of the regular operating instruments, only a few definite tools are needed (Fig. 1), such as: (1) 3 steel bone pins, (2) 3 turnbuckles fitted with right angle ends, (3) an orthopedic table or traction frame, (4) a circular or other satisfactory bone saw.

From the Surgical Clinics of the Nebraska Orthopedic Hospital, Lincoln, Nebraska.

The main steps of the operation are carried out in the following order:

1. Insertion of pin in os calcis and suspension of patient on the table (Fig. 2).
2. Osteotomy of the fibula (Fig. 3).
3. Osteotomy of the tibia (Fig. 3).
4. Insertion of a pin in lower and upper ends of tibia (Fig. 4).
5. Incorporation of steel pins and three turnbuckles in leg part of a double spica cast (Fig. 5).

The method as employed at the Nebraska Orthopedic Hospital consists essentially of the following:

The patient is suspended on the Hawley table in the customary way, except that a sterile Wyeth or Steinmann pin is driven through the os calcis of the leg to be lengthened and a sterile muslin strip is placed over each projecting end of the pin, is crossed, and is tied tightly to the cross bar at the base of the footpiece (Fig. 2). The leg is

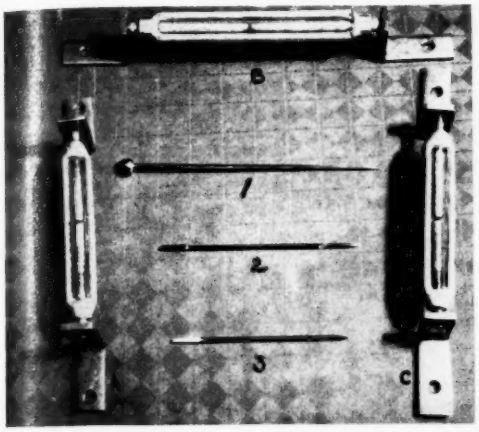


Fig. 1. *A*, *B*, *C*, Three turnbuckles fitted with right angle ends; *1*, Wyeth bone pin; *2*, *3*, different length Steinmann pins.

surgically prepared and draped with sterile towels and sheets as needed. A 7 to 8 inch incision is made either to the inner or outer side of the crest of the tibia so the suture line will not be over the crest. At this stage an oblique osteotomy of the fibula is done through a separate lateral incision or through the original incision. The sides of the tibia are freed of all soft tissue for almost the length of the incision and a circular motor saw cuts longitudinally down the middle of the tibia

Fig. 3.

Fig. 4.

Fig. 3. Dark line shows direction of osteotomy of tibia and fibula.
Fig. 4. Shows Steinmann pin in lower and upper ends of tibia and the suspension of leg to bracket above.

Fig. 2. Pin through os calcis, sterile muslin strip over each projecting end. The strips are crossed and tied to crossbar of foot piece. Patient on Hawley table.

for 5 to 7 inches. A chisel or saw, depending on the accessibility, cuts the lateral half of the tibia at the distal end of the longitudinal cut, and then the medial half of the tibia at the proximal end of the longitudinal cut (Fig. 3). The periosteum is divided at the same level as the last two cuts and then the fascia is cut according to indications presented.

The circular saw does not entirely cut through the posterior tibial cortex in the longitudinal cut, so a thin chisel completes this bone cutting. A short Steinmann pin is now placed through the lower portion of the tibia and then a second and longer one is driven through the tibia just below the tuberosity (Fig. 4).

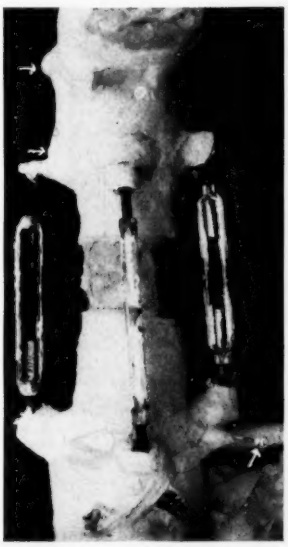


Fig. 5. Anterior view looking from above knee toward foot. Each lateral turnbuckle is turned in a horizontal plane and the anterior one in a vertical plane. Note incorporation of bone pins and turnbuckles in cast.

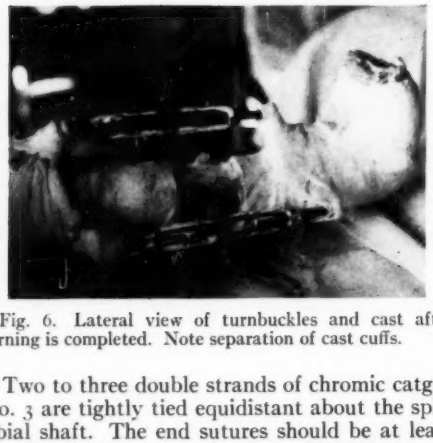


Fig. 6. Lateral view of turnbuckles and cast after turning is completed. Note separation of cast cuffs.

Two to three double strands of chromic catgut No. 3 are tightly tied equidistant about the split tibial shaft. The end sutures should be at least 1 inch from the cut ends of the tibial shaft and special care is taken to include no soft tissue in the sutures encircling the bone. The extension wheel to the foot attachment of the Hawley table is now tightened and some length is gained before the wound is closed by using chromic catgut for the fascia and plain catgut for the skin. Catgut is used for the skin so that the dressings need not be disturbed for the removal of sutures at a later date. The oftener dressings are tampered with the more certain is infection to occur. A vaseline gauze strip covers the entire suture line and favors seepage of serum and tissue fluids, and thereby lessens swelling. Sterile dressings are placed over the vaseline gauze, and then sterile sheet wadding is wound about the leg and pins. A sterile muslin strip is looped over each projecting end of the proximal tibial pin and tied to the overhead swinging bracket (Fig. 4). These strips should be tight enough to release the tension on the original muslin strip, in case one is used, supporting the knee in a slightly flexed position.

Cotton sheeting is wound about the leg and felt pads are placed at the customary areas needing protection. Plaster-of-Paris bandages encircle the leg and at convenient turns are wound about the respective ends of the pins in the upper and lower ends of the tibia and os calcis so as to anchor them firmly in the cast.[1] After one half of the customary thickness of a leg cast is applied and the plaster starts to be a little firm, a turnbuckle is placed slightly over half way down on each side of the leg and one on the anterior surface (Figs. 5 and 6). The ends of the three turnbuckles must be firmly incorporated in the outer layers of the cast and be equidistant from each other in the longitudinal planes (Fig. 5). The anterior turn-

[1]According to the skeletal fixation in plaster-of-Paris technique employed by Dr. Orr since about 1920.

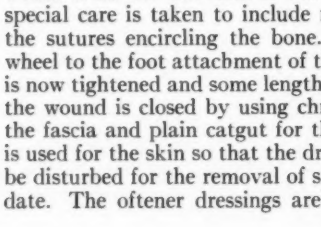
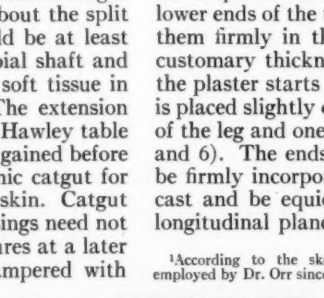


Fig. 7.



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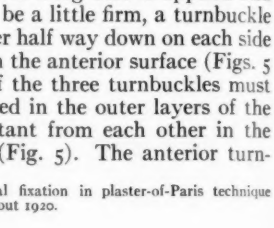

Fig. 9.

Fig. 7. Anterior and lateral roentgenograms of tibia and fibula 3 months after lengthening operation. The arrows indicate the amount of lengthening and the extent of the repair.

Fig. 8. Anterior and lateral views of tibia and fibula 10 weeks after lengthening operation.

Fig. 9. Anterior and lateral views of tibia and fibula 3 months after lengthening.

buckle is essential to insure stability and prevent slight motion or play. It is not necessary for the ends of the turnbuckles to be against the projecting ends of the bone pins, and it is easier to place them correctly if this is not attempted. It will be remembered that the pin ends are all held solidly in the cast, and any force applied on the leg cast also transmits the same force to the pins. The plaster bandages encircling the leg at the operative site need to be only of four or five layers (Fig. 6), as in the mid-area a circular cut is made on the third postoperative day so the upper and lower cuffs may separate as the turnbuckles are turned (Figs. 5 and 6). In order to control the leg adequately, a double spica or double leg cast is applied.

POSTOPERATIVE LENGTHENING OF THE LEG

Turning of the closed turnbuckles is started on the fourth postoperative day, and one to two full turns are accomplished each day thereafter until the desired length is reached and checked by x-ray examination. Making one-half or more turns twice a day is less annoying to the patient, and is carried out whenever possible to do so. By the last method mentioned, very little discomfort was experienced by the largest number of the patients. The two lateral turnbuckles are turned equally at the same time, and then the anterior one is turned an equal distance. By so doing, the original alinement is usually maintained (Fig. 7). If the right direction is not maintained by the tibial shaft, one or two turnbuckles can be turned separately or combined to make the correction.

It usually takes from 17 to 27 days to accomplish the desired length, which varies from 1.5 to 2.25 inches. It is usually difficult to get over 2 inches, and only in a few cases is it attempted, and then when conditions are favorable. The cast is left on 4 to 6 weeks after the turning is stopped, but the pins are removed in 4 weeks. A protective single leg cast is applied for another 4 to 6 weeks, depending on the extent of bone repair, and then a walking caliper is used for 2 to 3 months. In cases of very small spindle like bones, the caliper should be worn as long as conditions demand its use.

RESULTS

The results were satisfactory in the large majority of these cases. In 4 cases the full desired length was not obtained, but as minor details of technique were corrected, a more uniform lengthening was obtained, and in no case was it more than 2.25 inches. In the majority of cases 1.5 to 2 inches was obtained. In the patient with the congenital shortening of the femur and tibia, a total increase in length of 4.75 inches was obtained, 2.5 inches in the femur, and 2.25 inches in both tibia and fibula.

CONCLUSIONS

1. A simplified turnbuckle procedure for lengthening of the tibia and fibula is presented which can be used by a large number of bone surgeons. With slight modifications the same procedure may be used for other bone lengthenings, such as the femur. The overlapping of tibial fragments in leg fractures may be handled in a similar manner, and thus correct alinement attained. The same turnbuckle extension principle is also used in pulling down high dislocations of congenital hips.

2. The apparatus necessary for this method of lengthening is inexpensive, easy to obtain, and readily controlled.

3. The two lateral turnbuckles and tibial bone pins furnish the necessary traction and countertraction to the bone and soft tissue, and the anterior turnbuckle controls displacement in the anteroposterior direction. Two steel pins placed several inches apart in the upper tibial fragment will further prevent anterior displacement whenever this may be thought to be necessary.

4. By this method it is unnecessary to lengthen the Achilles tendon.

5. The results obtained are equal to any obtained from the use of more complicated and more expensive apparatus.

I acknowledge my indebtedness to Dr. H. Winnett Orr, chief visiting surgeon, for suggestions and the use of cases in making a report of this series of lengthenings.

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MARCH FRACTURE

Deutschlaender's Krankheit, Marschgeschwulst, Fussgeschwulst, Marschfraktur, Fracture-de-Recrue, Pied Debile, Pied Forcé, Pied de Marche, L'Enflure du Pied, Pied Surchargé

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THE dictates of extreme fashion in modern footwear, the sedentary habits to which most of us too easily submit, and the ubiquity of an overdeveloped transportation service, all have contributed to lowering of the normal muscular tone of the American people to such an extent that complaints concerning the feet today are among the commonest heard by members of the medical profession. When to the aforementioned factors is added the casualness with which the average physician regards what to him is a minor malady, there is at hand one of the main causes for the flourishing state of extraprofessional groups. We would suggest therefore that the practitioner consider march fracture as a possible diagnosis in every case of painful feet in which a complaint is made of sudden onset of symptoms following unaccustomed and excessive exercise.

Most of the literature on this subject has come from the pens of European authors engaged in the care of soldiers whose daily lot was excessive marching and weight-bearing. A lesion, which is likely to be confused with malignancy, but which can be recognized and which does respond to treatment, should be of interest to every practicing physician.

The credit for the original description of what is now recognized as march fracture must be given to Breithaupt. In 1855 this German military surgeon reported on several cases of persistently edematous and painful feet occurring in soldiers following forced marches. To this condition he applied the name *Fussgeschwulst*. From his observations he was of the opinion that the condition was the result of an inflammatory reaction in the tendon sheaths, traumatic in nature, and a direct sequel of the untoward strain to which certain feet were subjected during a march. In 1877, Weisbach described a similar condition which evinced itself 2 to 3 days following a route march. Although he agreed with Breithaupt's opinion regarding the etiology, Weisbach considered that the pathological lesion affected the ligaments rather than the tendons and their sheaths and applied the term *syndesmitis metatarsea*. In 1887 Pauzat, as the original French investigator, put forward the hypothesis that the causal factor was to be found in the dorsal fold of the soldier's shoe. He believed that the first stage was that of simple swelling of soft tissue but that this was followed by periosteal proliferation, the sequel of irritation set up by the shoe-fold, resulting in definite osteoplastic periostitis. In 1888 Poulet, also speaking from his experience in the French army, suggested the "rheumatic diathesis," as the predisposing factor, an hypothesis more in keeping with the trend of modern thought. Three years later, in 1891, Martin first suggested that the symptoms were produced by synovitis and arthritis of the joints of the fore part of the foot. He reported on three causes: (1) simple periostitis, (2) tendinitis alone, and (3) periostitis complicating mediotarsal arthritis. A review of the whole subject was published in 1897 by Busquet in which he divided the cases into two categories: (1) traumatic, and (2) diathetic, but even in this latter group he admitted that whereas predisposition, the result of some general condition, might exist, the localizing factor was traumatic. With the advent of roentgenology, much that was pure hypothesis was swept away and in examination of 35 patients described by Stechow, who was the first to examine his patients by this method, the lesion behind march foot was demonstrated to be fracture of a metatarsal bone. In the same year, 1897, Schulte in reporting a series of 53 cases stated that in all the causal factor was a fracture. He described a typical case, that of a soldier who after a long march returned to camp with a burning sensation in the middle portion of his right foot. The following morning, in spite of a swollen foot, he undertook an hour's march. Pain and swelling

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increased; the discomfort was maximal on pressure over the proximal half of the second metatarsal bone. There was no pain over the first and fifth metatarsal bones. Twenty days later a firm lump made its appearance, corresponding to the region of the greatest tenderness. Roentgenologic examination gave evidence of a mass which was the result of the formation of callus around a fracture. In 1899 Thiele reported on 17 cases which occurred in a single battalion in 3½ months. On roentgenologic examination 15 of these patients gave evidence of fracture. He considered the lesion to be the result of indirect force and drew attention to what he claimed was the sequence of events in this condition. He claimed that prolonged flexion of the bones led to an inflammatory reaction and in cases in which the force continued to act a fracture occurred. Momburg, writing in 1904, agreed with this conception of an inflammatory reaction leading to proliferation and subsequent fracture when the strain continued. He performed roentgenologic examination of the feet of many soldiers who made no complaints referable to the feet and he demonstrated silent periosteal proliferations of the second and third metatarsal bones in several of the cases. Kirschner, in 1905, when reporting on 82 patients, agreed with Schulte and Runström that in all cases the condition resulted from fractures or infractions, which were perhaps not noticed at first but, he said, if careful re-examination were carried out his claim would be confirmed. He considered that all such conditions followed exhaustion of the muscles of the foot. Physicians are indebted to Baehr, 1913, for his study of the mechanics of fracture.

Deutschlaender, in 1921, in his second contribution to the study of this subject, suggested a bacterial factor in the etiology of this condition. His views were based on 6 cases in all of which the patients were women. In 3 cases there was fever of low grade; formation of callus, which normally was present in 3 to 4 weeks, did not appear until the ninth week. He considered that the cause in those 3 cases was hematogenous bacterial periostitis of low grade. Although Deutschlaender's name has been given to march foot because of his early work on the subject, research has shown that Breithaupt was the original investigator in this field. Trethowan in 1921, and Jones and Lovett in 1923, in treatises on orthopedic surgery, referred to march foot as *pied forcé*.

Thalwitzer considered that march foot was caused by periostitis and that fractures were present only when demonstrated. Tobald, in an analysis of 1500 cases, found fracture in 49.7 per cent, periostitis in 11.9 per cent, old fracture in 5.7 per cent, and no fracture in 32.7 per cent. Blecher, in an investigation of 78 patients, was the first to draw attention to recurrences of old fractures. He reported 2 cases in which fracture had recurred for a third time. Speed and Blake also grouped their cases into: (1) those in which there was no tumor, roentgenologic findings were negative, and recovery was complete in 7 to 10 days; and (2) those in which the duration of symptoms and disability were prolonged, lasting 3 months, callus was excessive, and a fracture line was usually, but not always, seen.

Perhaps the most acceptable view is that of Zeitlin and Odessky, who concluded that march fracture occurred as a result of overloading a foot already weakened functionally and anatomically. The number of hypotheses advanced to explain this condition indicates the uncertainty which still shrouds its origin. Inflammatory factors doubtless are present in a small proportion of cases. In others, neurogenic influences probably play their part, but without doubt in the great majority of cases the condition is the result of trauma of greater or lesser degree to feet of which the functional sufficiency is well below par.

Honigmann drew attention to the similarity between this fracture and that which occurred in states of starvation, the so called spontaneous fracture. Turner invoked the influence of a trophoneurotic factor, while Blencke blamed high heels. It is to Jansen, who described 6 cases, that physicians owe the enunciation of the circulatory explanation, a view shared by Närvi. In 1926 Jansen suggested that spasm of the interosseous muscles led to hypertrophy of the muscle tissue and of the periosteum. Subperiosteal hemorrhages followed, he said, and this resulted in partial absorption of the bone, with resultant increase in brittleness and susceptibility to fracture. In substantiation of this claim he pointed out that periosteal changes never were noticed on the outer border of the fifth metatarsal or on either border of the first metatarsal bone, the only regions from which the interossei do not arise. The Sloanes considered that flat feet led to secondary disturbances of circulation of the foot, increased brittleness of bone and an increased tendency to fracture. Dodd claimed that a short first metatarsal bone, by throwing the foot into pronation and bringing the stress and strain of weight-bearing on the second metatarsal bone, was the predominating factor. Meiser's views are in concord with those of Dodd, while Morton's four points give additional support to Dodd's

claim; three of these points are that the first intermetatarsal space is prolonged backward, that the first metatarsal bone is short, and that posteriorly situated sesamoid bones at the head of the first metatarsal have virtually the effect of shortening the first metatarsal bone. These factors lead to the change which constitutes the fourth point, namely, compensatory enlargement of the shaft of the second metatarsal bone, but if hypertrophy is inadequate and the strain continues, fracture is likely to occur.

March foot has been a subject of sporadic interest since its original description by Breithaupt. There have been definite cycles of interest alternating with periods when the literature has been devoid of even the briefest reference to the lesion. Originally considered to be exclusively one of the hazards of a military career, it has more recently shown itself as a liability of ordinary civilian existence. Undoubtedly it is much more common among men who follow an active career, such as that led by the average soldier, who as a recruit may undergo forced marches and physical drill daily, but among traveling salesmen (Goldman), waitresses, and shop attendants, cases are far from rare. Although the fold of the shoe in the average military boot may be responsible for considerable discomfort, the site of pressure does not uniformly correspond to the situation of periosteal proliferation and fracture found in examination of patients with march fracture. Muscular spasm, with resultant circulatory interference, has been advanced as an explanation of many of those cases in which periosteal proliferation is found. However, to account for the sudden fracture, in association with which evidences of change in density of bone and periosteal hypertrophy are lacking on roentgenologic examination, this explanation is hardly adequate.

From our personal experience and from a review of the literature of this type of fracture, it would seem that the majority of the evidence points to the lesion occurring in those feet which are physiologically inadequate, be the cause what it may: anemia, hypotonic muscles, short first metatarsal segment, and so forth. Continued and repeated strain, such as that sustained on a long route march, or the stress and strain of excessive standing, aggravated by the necessity of supporting extra weight, may result in rupture of that metatarsal bone on which the greatest strain is placed. The comparative rarity of the condition among members of the general public probably is explained by the promptitude and ease with which the average person can rest when fatigued. It would be of interest to make, and we propose to carry out in the future, a series of investigations of the concentration of calcium, phosphorus, and phosphatase in the blood of victims of this lesion.

March foot might be defined as a fracture of the second or third or fourth metatarsal bones without known adequate cause. The condition most commonly affects the second metatarsal bone. Nion, in his series of 575 cases, found the second metatarsal bone affected in 112, the third metatarsal bone in 98, and the fourth metatarsal bone in 17; the first was involved in 1 case only. In his entire series fracture was proved definitely to have occurred in only 228 cases. One cannot place too much reliance on the roentgenologic findings because not infrequently a bone, at first roentgenologically negative, has been found on a roentgenologic examination made several weeks later, or at operation, to be fractured. Speaking generally, the first and fifth metatarsal bones are not affected. As a rule only one bone is affected but cases have been described in which two bones in the same foot have been involved and Saves described a condition in which the second and third metatarsal bones were affected on the right and the first and second metatarsal bones on the left. In our group one case is cited in which a similar bilateral involvement had occurred. The site usually is either the middle or the proximal third, but in our patients the fracture occurred in the distal half of the metatarsal bone.

PREDISPOSING CAUSES

Predisposing factors include fatigue of the muscles and ligaments; circulatory interference and increase in weight; large, badly fitted shoes, which do not support the fore part of the foot, and flat feet. In short, there is no single predisposing cause but a summation of several minor factors breaks down a natural resistance.

EXCITING FACTORS

Sudden, quick steps and repeated subminimal trauma are the exciting causes. In most cases in which roentgenograms are made, anteroposterior, lateral, and oblique views will show a thin line of fracture in the shaft of the metatarsal, without displacement, but, in an appreciable proportion of cases, no solution in continuity of bone is seen. In many cases of this latter group, however, subsequent roentgenologic examination, after 5 to 6 weeks, will demonstrate the presence of a fracture. We believe that the periosteal proliferation results from constant irritation in an imperfectly immobilized fracture that is subjected to the stress and strain of weight-bearing and motion. As a result of stripping of periosteum and collec-

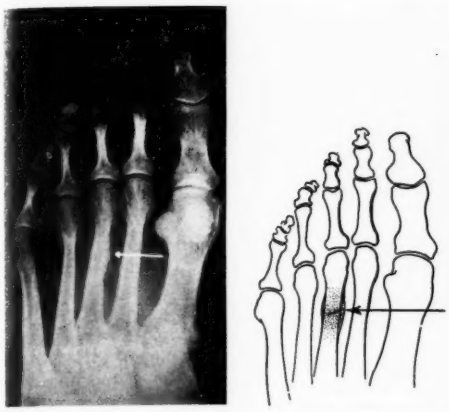

Fig. 1, a and b. The fracture passes transversely through the third metatarsal bone and callus.

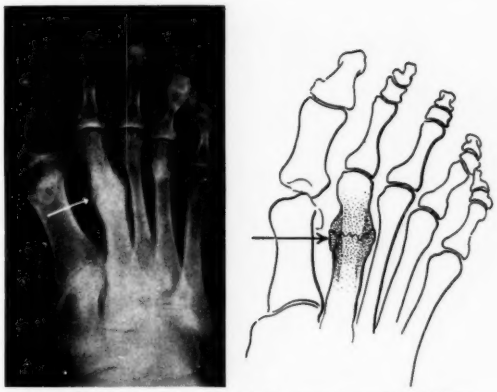

Fig. 2, a and b. Fracture of the second metatarsal bone and marked formation of callus in hypertrophied second metatarsal bone. The head of the first metatarsal bone had been excised for hallux valgus.

tion of fluid from irritation at the site of fracture, there is a gradual periosteal proliferation, which becomes roentgenologically evident after 3 weeks. This spindle-shaped periosteal formation in the shaft of the bone, with unrecognized fracture, has led to the erroneous diagnosis of sarcoma. It is interesting to consider Deutschlaender's findings in his report of 1921, on those cases of possibly infectious nature, wherein callus did not appear until the ninth week.

SYMPTOMATOLOGY

In the vast majority of cases the first symptom is an ache or burning pain in the fore part of the foot, for which the patient is unable to account. The discomfort may be felt only when weight is put on the foot, rest giving complete relief, but in other cases a dull ache is constantly present. In those cases in which the patients are soldiers, the pain occurs in the course of a march. In some such cases it is so severe that the men are unable to walk; in others, they are forced to lighten their equipment, while in others again, the discomfort is not very prominent and the men may even continue at their usual duties without much complaint. Swelling is present on the dorsal aspect in cases of minor degree, but in those in which symptoms are very marked, edema is obvious on both the dorsal and plantar surfaces. The edema is usually localized to the region which lies above the bones involved but in some cases it may extend up as far as the ankle joint. Ecchymosis is not present. In our series two patients had, in addition to pain and swelling, definite erythema over the dorsum of the foot.

In 5 cases of our series a history of trauma could not be elicited, even on pointed inquiry. In 3 cases a minor degree of trauma might have been a causal factor, for the pain of one patient developed in the course of a game of tennis; that of another, immediately on taking a forceful step forward, and a third admitted to a period of unusual exertion while she was on a camping holiday; in no case of the 3, however, was there any suggestion of definite direct injury. Another patient, a tall, slim young physician, said that before the onset of his pain he had been subjected to the excessive strain of overwork. For years he had worn arch supports. This would tend to confirm the opinion we hold that march foot afflicts those patients whose feet are already weak but are adequate until some sudden or long continued strain affects the weakest of the metatarsal bones and fracture results. Tenderness, with pain on walking at the site of fracture, is the most outstanding sign.

SEX AND AGES OF PATIENTS AND SITE OF FRACTURE

Although men are predominantly the victims, in our practice women have been more often afflicted with this condition. In our series 7 patients were women and 3 were men; their average age was higher than that usually reported; it was 39¾ years. The youngest patient was 19 years of age and the oldest, 61 years. In our group the left foot was involved in 4 cases and the right in 5, while in the tenth case fractures occurred in both feet. In this tenth case the second metatarsal bone of the left foot was frac-

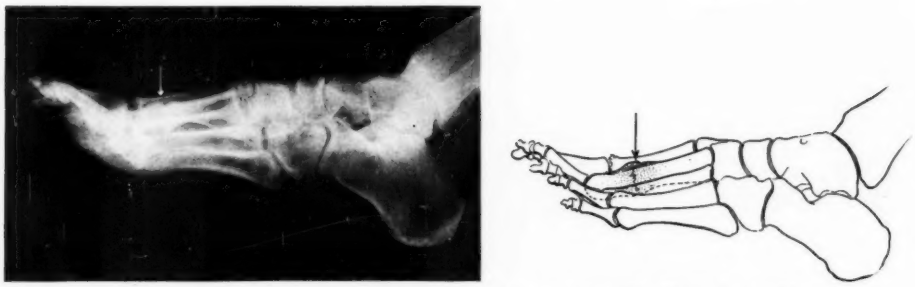

Fig. 3, a and b. Lateral views of same foot as that represented in Figure 2, a and b.

tured and roentgenologic evidence pointed to old fractures in the second and fourth metatarsal bones of the right foot. As a rule, one bone only is attacked and usually the condition is unilateral. We found, on reviewing our cases in the light of roentgenologic findings, that in 1 case the second and third metatarsal bones of the left foot were affected, while in another case, although the second metatarsal bone was the source of the trouble which caused the patient to seek our advice, the roentgenograms gave evidence of deformity of the head of the fifth metatarsal bone of the same foot; this deformity was strongly suggestive of an old fracture. In still a third case fractures were found in the shaft of the fourth metatarsal bone and in the proximal phalanx of the fifth toe of the left foot. One of our patients had double hallux valgus, which might have been a predisposing cause, and another had undergone excision of the first metatarsal head; 2 had worn arch supports for several years. Maseritz reported a case in which there were fragmentation of the internal cuneiform bone, fracture of the head of the second metatarsal bone, and fracture of the base of the fifth metatarsal bone.

PROGNOSIS

The prognosis is uniformly good. In the early stages changes may not be noticeable but after 2 weeks periosteal fuzziness is distinctly discernible. By the third or fourth week exuberant callus is the rule, although in Deutschlaender's latter series this was delayed until the ninth week. As the fracture heals, the excessive callus is absorbed and after 6 months only residual thickness at the site remains as a clue to the preceding defect.

DIAGNOSIS

In any case of painful feet, a history of overexercise, of prolonged and excessive weightbearing, or of the wearing of arch supports for weak feet should, especially in the absence of direct trauma, cause the physician to think of march fracture and roentgenologic investigation should be carried out; the physician should not attribute the symptoms of pain, swelling, or even fine crepitation to the simpler tenosynovitis. It must be borne in mind, however, that not infrequently the roentgenologic report may be negative for fracture. A practical point in examination of the roentgenograms is inspection of the films held at varying angles to modify the intensity of illumination; too brilliant light frequently masks the hair-line shadow of the fracture. Furthermore, an oblique view should be taken, for in certain cases a hair-like line of fracture, invisible in the anteroposterior and lateral views, becomes apparent in the oblique exposure. Even when all three views are searched carefully, definite evidence of fracture cannot be seen in a certain number of cases; yet in a roentgenogram made 4 weeks later the shadow of the line of fracture may be distinct. In Straus' case, periosteal overgrowth of the metatarsal bone was obvious, but it was not until the bone had been removed at operation and sectioned longitudinally that the fracture became visible.

DIFFERENTIAL DIAGNOSIS

The only important conditions which are of concern here are (1) tenosynovitis and (2) osteogenic sarcoma. Straus reported a case in which the patient gave no history of trauma but in which a tumor was palpable in the shaft of the metatarsal bone and the roentgenograms disclosed the presence of a tumor but no fracture; the patient also complained of nocturnal pain and had lost appreciably in weight. We believe that when doubt exists as to the exact diagnosis, biopsy should be carried out and the opinion of an expert pathologist should be obtained to clear the issue. Swelling, superficial pain, tenderness, and local increase in temperature, with repeatedly

negative roentgenograms, definitely should distinguish tenosynovitis from other conditions.

One of us (Meyerding) had a case in which the patient's own physician reasonably enough had made a diagnosis of sarcoma and had advised immediate amputation. The question of march fracture arose but the other features were so much in favor of the more serious condition that a preliminary biopsy was decided on and at operation the simpler condition was proved to be present on microscopic examination of tissue. Dodd reported a case in which amputation was carried out, and it was not until the specimen was examined by a pathologist that the true nature of the tumor became apparent. Syphilitic periostitis can be excluded by flocculation tests; these are carried out routinely in all of our cases.

TREATMENT

Vis medicatrix naturæ is as potent a therapeutic factor in march fracture as it is in many of the other ills to which flesh is heir. No doubt many a soldier in times gone by was cured by time and rest alone. In this modern age, relief of pain is demanded by the soldier as vociferously as by the merchant, and no measures are more effective in relieving discomfort than rest, together with heat in the form of diathermy or infra-red light. Specially made arch supports are effective, as are splints of tongue depressors applied with adhesive tape. A wide toed, well fitted, heavy soled boot with an elevated, large, square heel, and the aid of a crutch or cane, enable the patient to get about with minimal discomfort. In certain cases in which the patient must continue at his work we have applied a plaster cast from the knee to the toes, with successful results.

REPORT OF CASES

In the cases which now are to be reported, relevant laboratory examinations of the urine and blood and other special examinations were made without disclosing anything that bore on the condition here discussed.

CASE 1. A woman, unmarried and aged 33 years, reported for examination on June 18, 1936. Her height was 5 feet (152 cm.) and her weight 126 pounds (57 kg.). At the time of admission she complained of pain in the left foot of 7 to 8 months' duration and said that pain had come on following a game of tennis. She had been examined and roentgenograms had been made elsewhere some months previously, with negative findings.

At the time of our examination the general physical findings were negative and roentgenograms gave evidence of an old fracture of the left third metatarsal bone, with periosteal reaction mesially (Fig. 1, a and b).

CASE 2. A butcher, aged 53 years, reported for examination on May 9, 1927. His height was 6 feet (183 cm.) and his weight 150 pounds(68 kg.). On admission he complained of pain in the left foot of 3 days' duration, but he did not give a history of trauma. He stated that pain had begun in the fifth toe, along the outer side of the foot, and that swelling had occurred and had extended to the right side of the ankle.

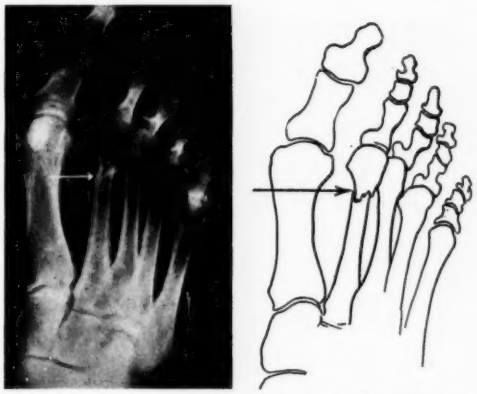

Fig. 4, a and b. Fracture of the distal third of second metatarsal bone of left foot, with slight displacement and without periosteal proliferation.

General physical examination gave negative results. Roentgenograms gave evidence of fracture of the proximal phalanx of the fifth toe of the left foot and of the shaft of the fourth metatarsal bone.

CASE 3. A housewife, aged 47 years, reported at the clinic in 1926, at which time her height was 5 feet, 7½ inches (171 cm.) and her weight 174 pounds (79 kg.). On admission she complained of attacks of swelling and pain of the dorsum of the right foot, of 2 months' duration. She attributed her symptoms to an operation for bunion that had been performed elsewhere 1 year previously. A history of trauma could not be obtained on inquiry.

Roentgenologic examination demonstrated that (1) the head of the first metatarsal bone of the right foot had been excised as a step in the treatment of her hallux valgus and (2) that a thickened second metatarsal bone had been fractured in its middle third, without displacement but with marked formation of callus (Fig. 2, a and b and Fig. 3, a and b). Our interpretation of the findings was that, as a result of excision of the head of the first metatarsal bone and the consequent shortening of this segment, pronation of the foot had occurred, throwing increased strain on the second metatarsal bone. Compensatory hypertrophy of the second metatarsal bone occurred but this was not sufficient to support the weight; as a result fracture occurred.

CASE 4. A woman, unmarried, and 50 years of age, reported for examination on November 11, 1928. Her height was 5 feet, 7½ inches (171 cm.) and her weight 163 pounds (74 kg.). She complained of pain, swelling and stiffness of the left foot when walking, of 6 months' duration. While she had been walking with a blister on the foot, she had noticed pain and swelling over the metatarsal bones. A history of trauma could not be elicited, but recently the patient had increased in weight.

The diagnosis of fracture was not made on first inspection of the roentgenograms but when they were reviewed

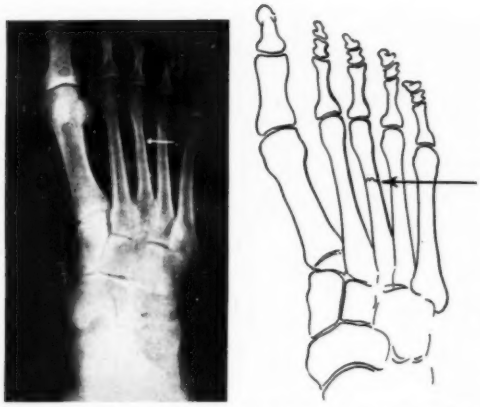

Fig. 5, a and b. Fracture of the distal third of third metatarsal bone.

at consultation a diagnosis of old fracture of the second metatarsal bone of the left foot was made; moreover, evidence of a more recent fracture of the third metatarsal bone was found.

CASE 5. A female nurse, aged 21 years, reported for examination on August 2, 1920. She complained of pain in the right foot and stated that 4 days previously, while going upstairs, she had felt something "pop" in the region of the second toe. Hot fomentations and rest had resulted in relief of the condition but walking had aggravated it and caused more pain and swelling of the foot.

On examination, diffuse swelling and tenderness over the second metatarsal bone of the right foot were found, while on the plantar aspect of the head of the second metatarsal bone there were thick callosities. Roentgenologic examination disclosed the presence of a fracture of the second metatarsal bone. Eleven days subsequently, roentgenologic examination gave evidence of slight displacement of the fracture and of exuberant formation of callus.

CASE 6. A male physician, aged 34 years, reported for examination on February 1, 1936. His weight was 164 pounds (74 kg.) and his height 5 feet, 11 inches (180 cm.). He gave a history of pain and swelling of the feet developing 4 months previous to his admission.

On examination of the roentgenograms it was found that a fracture involved the middle of the shaft of the second metatarsal bone of the left foot, and there was suggestive evidence of an old fracture of the second and fourth metatarsal bones of the right foot. Multiple callosities and trichophytosis were found on examination of both feet. Further questions elicited the fact that the patient had been very active professionally, had overworked, and had become fatigued previous to the onset of his symptoms. He had worn arch supports for some time.

CASE 7. A woman, aged 48 years, reported for examination on July 5, 1927. Her height was 5 feet, 9 inches (175 cm.) and her weight 183 pounds (83 kg.). She complained of pain, swelling, and redness in the region of the fourth toe of the right foot, of 1 month's duration. She stated that the pain was present only when she walked and that recently she had gained weight. There was a history of the patient being unusually energetic while on a camping trip about a month previous to admission, but she could not recall having sustained any direct trauma.

Roentgenograms disclosed the presence of a fracture of the third metatarsal bone of the right foot.

CASE 8. A nun, aged 61 years, reported for examination on June 16, 1925. Her height was 5 feet, 4 inches (163 cm.) and her weight 124 pounds (56 kg.). She complained of pain in the right foot, of 3 to 4 days' duration. She recalled that she had experienced pain while she was very active looking after children and had taken a forceful step forward; beyond this there was no history of trauma to the foot.

Examination disclosed tenderness and swelling of the fore part of the right foot, with increased local tenderness and pain of the outer side. The patient formerly had worn rubber arch supports but for the past 2 months she had worn steel supports. Roentgenograms gave evidence of a fracture of the proximal end of the fourth metatarsal bone. Additional findings were bilateral hallux valgus with marked callus of both feet.

CASE 9. A merchant, aged 38 years, reported for examination December 5, 1933. His height was 5 feet, 10½ inches (179 cm.) and his weight 180 pounds (82 kg.). He complained that 1 week previously, without preceding illness or injury, he had been seized with pain and swelling in the fore part of the left foot. He said that he had been on his feet a great deal, preparing his shop for Christmas.

Roentgenograms gave evidence of a fracture of the distal third of the second metatarsal bone of the left foot

Fig. 6, a and b. Lateral views of same foot as that represented in Figure 5, a and b.

(Fig. 4, a and b). There was slight displacement of the fragments, without periosteal proliferation. The roentgenograms also disclosed the presence of a deformity of the head of the fifth metatarsal bone of the same foot, probably the result of an old fracture. As the patient insisted on working, a cast of plaster of Paris was applied to the foot and he returned to his work. Three weeks later, he returned to the clinic and was found to be very much improved and free from pain. At this time he recalled that while in the Army, in 1917, marching caused him to become disabled by pain in the left foot. For the 4 years before he came to the clinic he had been treated for bilateral claw foot and painful callosities. Arch supports and transverse metatarsal bars had been prescribed for these conditions and had given him some benefit.

CASE 10. A female nurse, in training and aged 19 years, was under observation for secondary anemia when she came to the office complaining of pain and tenderness along the dorsum of the right foot and of pain along the extensor tendons of the third right toe, of 3 days' duration.

Foci of infection were not found. The patient's height was 5 feet, 3½ inches (161 cm.) and her weight 108 pounds (49 kg.). There was a moderate degree of bilateral flat foot. Crepitus could not be elicited on examination. The consulting orthopedic surgeon thought that the condition of the right foot was the result of tenosynovitis and strapped the foot. The woman felt better for 2 days following this and then the condition was worse and pain continued. Roentgenograms disclosed the presence of a subperiosteal fracture of the distal third of the third metatarsal bone, without periosteal thickening (Fig. 5, a and b and Fig. 6, a and b).

In all cases treatment by means of rest, heat, and splinting resulted in satisfactory recovery.

SUMMARY

We believe that march foot, although infrequently recognized in civilian practice, does occur and may be entirely overlooked or confused with tenosynovitis or sarcoma. In the differential diagnosis, we wish to emphasize the difficulty of recognizing the shadow of the hair-line fracture in roentgenogram. It is our belief that the periosteal proliferation results from irritation at the site of fracture, and is the result of imperfect immobilization. We believe that biopsy should be carried out when any doubt exists as to the true nature of the condition.

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A NEW TYPE OF SUCTION APPARATUS

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MOST physicians with hospital practices have felt the need for a suction apparatus which is inexpensive, simple, dependable, and foolproof. The machine illustrated has answered this need so well at the Sonoma County (California) Hospital that it seemed worth while reporting. Over a period of some months it has given thoroughly satisfactory service on patients requiring stomach, bladder, gall-bladder, or chest drainage without a single mechanical difficulty.

The negative pressure is obtained through the upside-down siphon arrangement in common use, the only departure from the usual procedure being the use of two ordinary gallon bottles which empty into each other; reversal of the flow is produced by rotating the inside frame in which the bottles rest. Only one valve, for the air out-

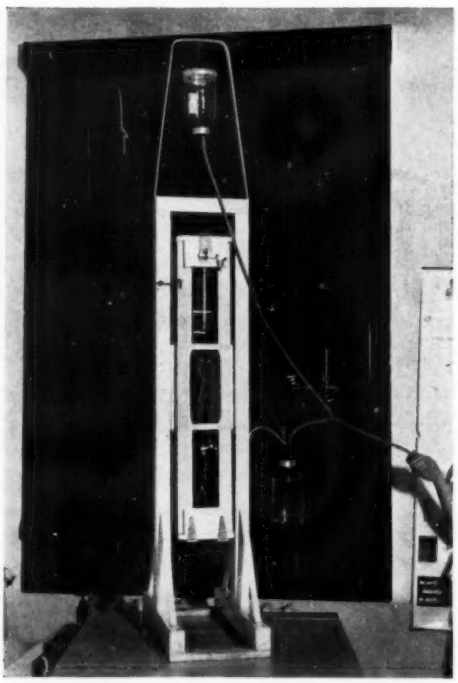

Fig. 1. Photograph of apparatus.

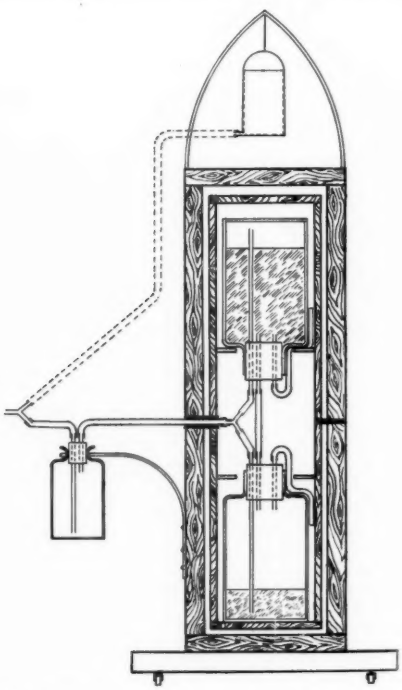

Fig. 2. Diagram showing construction of apparatus.

le', is present, and closure of this valve is produced automatically by the weight of the upper bottle. As will be seen from the diagram, the air outlet tube (I have used the thin tubing of the blood-counting pipettes) is led away from the rubber stopper between the neck of the bottle and the ring on which it rests. The frame allows the bottles approximately one-quarter inch movement in a vertical direction, and the lower bottle drops away from the tubing at the same time that the upper bottle drops onto it.

Our own apparatus was built of materials found in any hospital, and the carpenter estimates the cost as less than two dollars. Since only simple reversal of the inside frame is needed to keep the suction, the physician is spared the necessity for straightening out a complicated arrangement of tubes and bottles which is seldom understood by hospital attendants.

Construction details and the arrangement of the tubing and bottles probably call for no further explanation than the diagram. The irrigation (shown in dotted lines) and drainage bottles are those used for commercial intravenous solutions. The entire frame is mounted on casters and can easily be moved to any part of the hospital.

TECHNIQUE FOR THE RAPID AND ABSOLUTE STERILIZATION OF INSTRUMENTS

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ASEPTIC technique depends for its success upon the reduction to a minimum of the bacteria introduced into the tissues. Every operative wound is inevitably contaminated by air-borne bacteria (4, 9, 13, 20), and the bacteria present in the skin of the patient (1, 13, 19). The sterilization of the operative site and the hands of the surgical team is necessarily a relative matter, and is an attempt to reduce contamination to a minimum. The sterilization of instruments, dry goods, suture material, rubber goods, and solutions used during an operation is, however, under the control of the surgeon and can be made sufficiently thorough to destroy all bacterial life. Nevertheless, the common practice in sterilizing instruments, gloves, and sutures for the operating table does not insure absolute sterility (5, 6). Bacteriologists have repeatedly pointed out that boiling water does not kill spores even after prolonged exposure (5, 11, 16, 18). Abbreviated boiling periods (14), the use of oil on instruments (5, 16), the formation of scale in hard water areas (8), and depressed boiling temperature caused by altitude are additional factors causing inadequate sterilization. The safety of a technique based upon boiling depends upon the care with which spore-bearing organisms and spores have been excluded by mechanical means. Inevitable disaster results whenever dangerous spores are not removed from instruments prior to sterilization by boiling.

Even in operating rooms where supplies and the original instrument kits are adequately sterilized prior to operation there are opportunities for unsterile instruments or dangerous spores to reach the operative field. These breaks in aseptic technique are sanctioned by surgeons because there have been no reliable methods for either the emergency sterilization of instruments or the postoperative sterilization of instruments contaminated with oil, feces, blood, or pus known to contain virulent bacteria or spores. Two new types of sterilizers, designed for these specific purposes, have been in use at the Peter Bent Brigham Hospital for 2 years. They have proved to be such practical additions to the sterilizing facilities, that they have supplanted boiling sterilizers in the operating room.

The problem of emergency sterilization arises daily. Every surgeon is familiar with the exasperating delay caused by the omission of instruments from the kit, or has been inconvenienced by inadvertently dropping a special instrument or has been forced to wait for instruments required by a change in the operative procedure caused by unexpected pathology. In many clinics "quick sterilization," boiling for one or two minutes in a small electric sterilizer, or chemical disinfection, "just wipe the instrument with a germicide," are sanctioned because of the emergency. In operating rooms where more thorough emergency methods are used, the impatient surgeon may stampede a timid circulating nurse into returning an instrument to the operative field before it has been adequately sterilized.

Safe emergency sterilization can be carried out quickly and efficiently in a specially designed and constructed, steam jacketed autoclave of the conventional horizontal type (Fig. 1). The accessory equipment, steam pressure regulator, operating valves, air ejector and piping have sufficient steam capacity to complete the sterilizing cycle in a chamber 9 inches in diameter and 19 inches long in less than 4 minutes. Operation is simple, easy, and sufficiently quiet so that the sterilizer can be used in the operating room without causing annoyance.

Steam is admitted to the jacket of the emergency sterilizer prior to an operation, and a steam pressure of 27 pounds (gauge pressure) is maintained until the operative procedure is finished. Thus the sterilizer is instantly available and condensation in the chamber is eliminated. Before placing instruments in the sterilizer, gross dirt and grease must be removed by scrubbing with soap and water and slushing in a fat solvent.[1] The clean, fat-free instruments are placed in the sterilizer on a perforated metal tray and the door is closed tightly. Steam is then admitted to the chamber so rapidly that a sterilizing temperature of 273 degrees F. is attained in 40 seconds.

From the Surgical Clinic of the Peter Bent Brigham Hospital and The Laboratory of Surgical Research, Harvard Medical School.

[1]Ether, acetone or xylol may be used. A commercial solvent such as Stod-Sol will be found less expensive and has the advantage of being non-explosive.

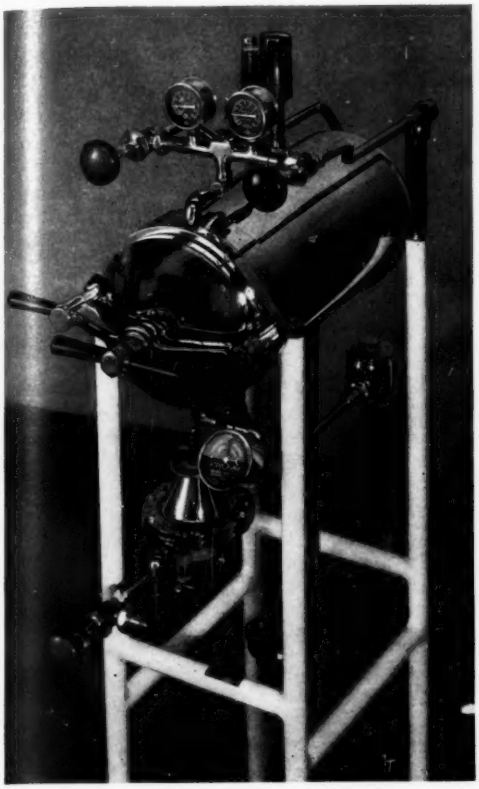

Fig. 1. The specially constructed, high speed autoclave permits the rapid sterilization of instruments in 4 minutes.

Spores of the most heat-resistant organisms can be destroyed at 273 degrees F. in 2 minutes (2, 3). An automatic, recycling timer meters a consecutive sterilizing interval of 3 minutes and signals that the load is sterile and that the steam may be vented. Pressure in the chamber can be relieved almost instantaneously. A detachable handle is then fitted to the sterilizing tray and the instruments can be carried to the operative field without danger of dropping or contamination (Fig. 2). This technique enables the circulating nurse to return an instrument to the operating table with no compromise of aseptic technique less than 5 minutes after it was dropped to the floor (Fig. 3). Because of the rapid action and high temperature attained in this sterilizer, spotting and corrosion of instruments are eliminated. Hence preheating and drying periods are unnecessary.

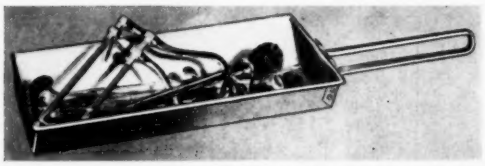

Fig. 2. Sterilizing tray with detachable handle provides for safe transport to the operative field.

The second problem in protecting asepsis, the disinfection of instruments from septic cases or instruments soiled by pus or feces where spore bearers are likely to be encountered, has received much attention. The danger of spore-bearing organisms in the operating room has been recognized and special techniques for the routine sterilization of such instruments have been devised. The number of techniques in use and the wide range of minimum standards for sterilization of these instruments are indications of the inefficiency of the existing methods of caring for "dirty" instruments. The only safe bacteriologic technique of those in current use is that of

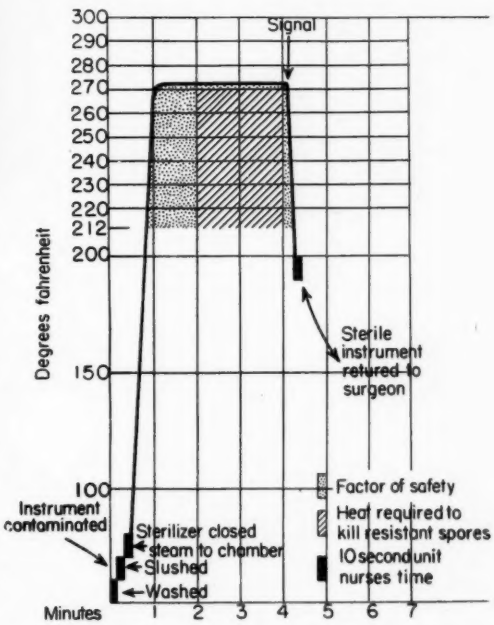

Fig. 3. A safe technique for the sterilization of instruments urgently needed by the surgeon provides for rapid, absolute sterilization. The chart illustrates the time and temperature relationships throughout the sterilizing cycle.

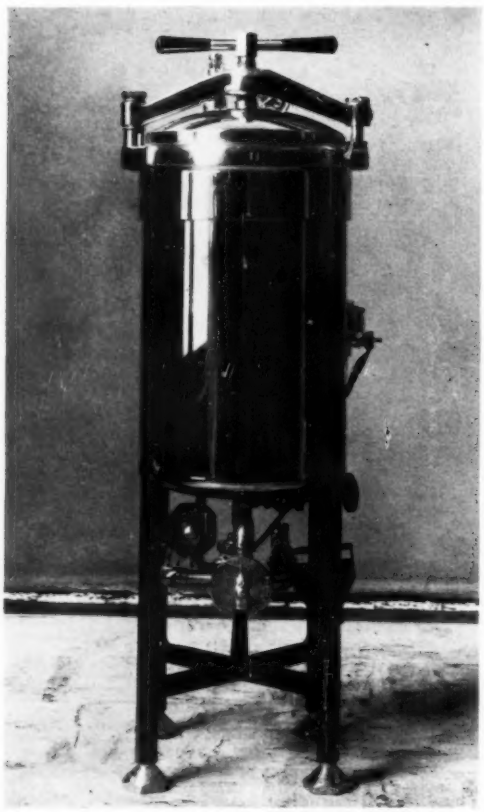

Fig. 4. The instrument washer and sterilizer frees instruments of blood, feces, pus, or grease, while they are being sterilized.

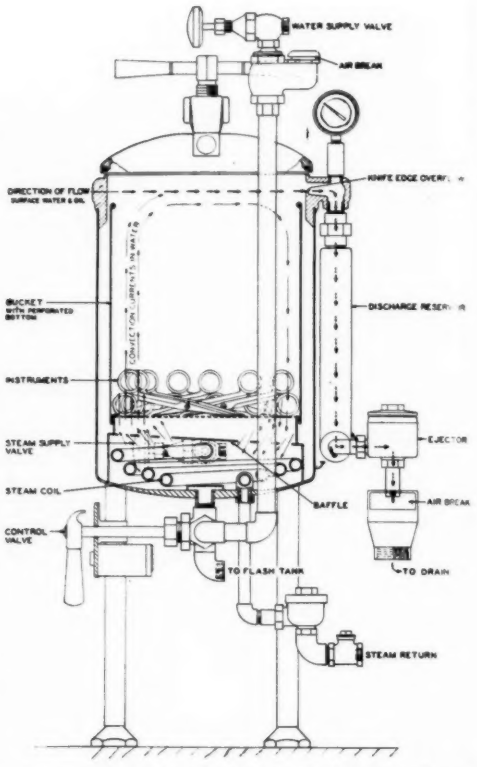

Fig. 5. Diagram of the sterilizer utilizing superheated water as the cleansing and sterilizing agent.

immersing the soiled instruments in a 10 per cent soap solution and autoclaving them at 250 degrees F. for 30 minutes. This practice has the disadvantage of using equipment primarily designed for another purpose. The interior of the autoclave is usually fouled with soap and denatured proteins which are spattered on the chamber wall when the steam is vented. The danger of scalding the attendants who remove the instruments from the sterilizer is great. Soaking dirty instruments in a germicide, prolonged boiling after thorough scouring and scrubbing, or combining these in various ways is not only time-consuming but also removes the instruments from circulation. What is of greater importance to safety, dangerous spores may be spread throughout the operating room during the cleansing process, or sterilizers may be contaminated with spores which survive hours of boiling.

A safe, rapid technique for the cleansing and sterilization of such instruments is that of exposing them to superheated water in a sterilizer designed to remove the oil and scum from the surface of the water, leaving at the most a monomolecular (12) film of oil which can be sterilized (16). This is done conveniently in a vertical autoclave constructed to withstand an operating pressure of 27 pounds per square inch (gauge pressure) (Fig. 4). The dirty instruments are collected in a stainless steel bucket directly from the instrument table. The bucket is placed in the sterilizer over a baffle which forces water to circulate through perforations in the bottom of the bucket (Fig. 5). A steam coil, located beneath the baffle, supplies adequate heat for rapid sterilization and sets up convection currents in the water to carry the oil and grease, which leave

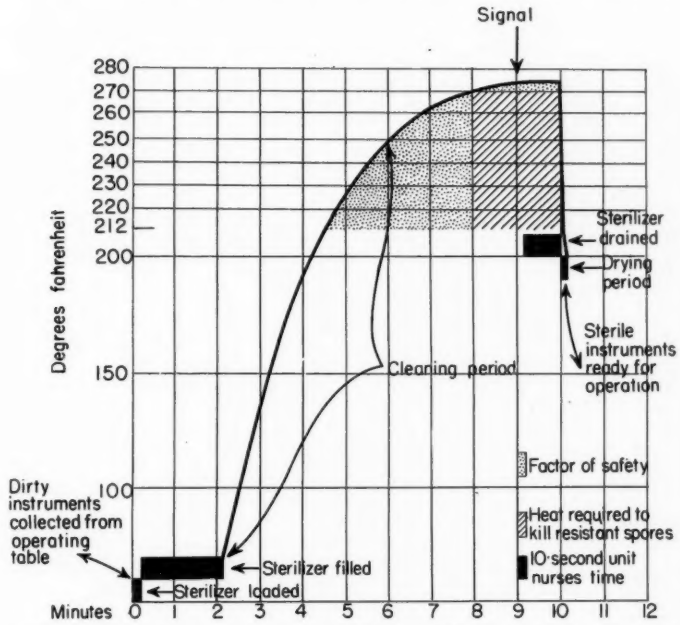

Fig. 6. Instruments can be cleaned, sterilized, and dried in 7 minutes. Time and temperature relationships of the superheated water sterilizer are charted.

the instruments and rise to the surface, toward an overflow at the rear of the sterilizer. The continual rise in the water level, due to the expansion of the heating water, carries the oils and scum formed by the blood and pus over a knife edge overflow into a reservoir whence it is discharged into the drain by a special ejector. The addition of a detergent, to peptonize the proteins and saponify and peptize the greases, removes all the dirt, eliminating the necessity for mechanical cleansing of the instruments. The use of sodium metaphosphate in the detergent (15) softens the water[1] and prevents the precipitation of a film of alkaline earth soaps and salts on the instruments (8). The temperature of the water is raised to 273 degrees F. in 7 minutes, a signal light indicating when the steam supply is to be shut off (Fig. 5). The superheated water is rapidly drained into a flash tank, exposing the instruments to saturated steam for approximately 1 minute while the pressure is being relieved. The residual heat in the instruments is sufficient to flash any adherent moisture and the clean, dry, sterile instruments are ready for immediate use upon removal from the sterilizer. The action of this sterilizer is so rapid and satisfactory that it

[1]The detergent, Calgonite (7), (Calgon, Inc., Pittsburgh, Pa.) contains:

Sodium hexametaphosphate	40
Tri-sodium phosphate monohydrate	15
Sodium metasilicate pentahydrate	40
Sodium hydroxide	5

When used in the concentrations shown in Table I, it will not damage surgical instruments (17) and will sequester the calcium ion and prevent the formation of films of insoluble adherent alkaline earth soaps and salts.

TABLE I.—CONCENTRATIONS

*Total hardness of water as $CaCO_3$		Ounces of calgonite to be added to sterilizer
G.P.G.	P.P.M.	
5	85	2
10	171	4.5
15	256	7
20	342	9
25	427	11.5
30	513	13.5
35	598	16
40	684	18
45	769	20.5
50	854	23

G.P.G.—grains per gallon.
P.P.M.—parts per million.
*Information may be obtained from local boards of health.

may be used for the routine sterilization of instruments, thereby supplanting less efficient methods.

These new sterilizers provide a safe, rapid method for emergency sterilization and a safe technique for cleansing and sterilizing instruments contaminated with spore-bearing material. Potential breaks in aseptic technique, sanctioned heretofore because safer methods were not available, are eliminated, permitting the practical establishment of a higher standard of asepsis.

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FRACTURES OF THE LOWER END OF THE RADIUS

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FRACTURES of the lower end of the radius constitute about 11 per cent of all fractures cared for at the Massachusetts General Hospital. During the period from 1918 to 1935 there were 870 cases of this fracture. Most of these patients were treated in the Emergency Ward and in the Out-Patient Department, so that detailed records of the treatment given and of the results obtained are not available. End-result studies were made primarily on the patients who were admitted to the hospital for care, either on account of other complicating injuries or because of unusual problems presented by the fracture itself. Thus, the cases studied are not truly representative of the entire series, and it is fair to assume that the results in the uncomplicated cases which were not followed up are superior to those in the cases studied.

The age and sex distribution of our patients was not remarkable. While the sexes were about equally involved, the fractures in males occurred primarily during adolescence, during the period of active physical life, while among females the middle-aged group showed the greatest frequency.

DIAGNOSIS

Because of the frequency with which the injury is seen and the characteristic appearance of the wrist, the diagnosis of Colles' fracture is generally made from clinical examination alone. This is not always true, however, for in a surprisingly large number of the patients in our group the correct diagnosis had not been made by the first physician who treated the injury.

In general the patient comes in carrying the hand in a sling position and giving the typical history of a fall on the outstretched hand with immediate pain and disability. Upon examination there are noted swelling of the wrist and marked tenderness, localized over the fracture. Obvious alteration has occurred in the surface landmarks producing a characteristic silver fork deformity. The hand appears to be displaced backward and abducted in relation to the forearm. Abnormal mobility or crepitus may be present but are unusual. An x-ray examination should be made whenever there is the slightest suspicion of injury and should be relied upon to disclose the full details of bony damage and displacement.

The exposures should be made in both anteroposterior and lateral planes. One should bear in mind the possibility of an associated injury to one of the carpal bones and roentgenograms should be carefully scrutinized to clarify this point. The clue to the amount of displacement is to be found particularly in the films made in the lateral plane. Normally the plane of the distal surface of the radius is directed slightly forward so that it forms an angle of 85 to 80 degrees with the longitudinal axis of the shaft. Displacement is manifested by alteration in this relationship, the articulation facing backward to greater or lesser degree. Restoration of the normal angle of the articulation is important from the standpoint of recovering the ability completely to flex the wrist. When there is doubt as to the amount of displacement, films should be made of the normal wrist for purposes of comparison. In addition, to the amount of displacement, degree of comminution, and impaction which can be observed in the x-ray films, attention is called to the position of the ulnar head as seen in the lateral view. Any tendency for the ulna to assume an anterior position suggests the disruption of the radio-ulnar joint through loss of the integrity of the triangular ligament.

MECHANISM

Through a fall on the outstretched hand the commonest fracture is a simple transverse fracture 1.25 to 2 centimeters above the joint margin. Displacement may be absent or present in varying degrees. Usually the distal fragment, carrying with it the hand, is displaced backward and upward with reference to the proximal fragment causing a foreshortening of the hand upon the forearm and resulting in the typical silver fork deformity. At the same time, the distal fragment tilts backward so that the articular surface of the radius looks backward instead of slightly forward as is normal. The distal fragment is also slightly rotated in the direction of supination with relation to the proximal fragment. Some degree of impaction is commonly present, the dorsal edge of the proximal fragment being driven into the distal fragment. Despite the displacement, comminution, and impaction, the problem is simply that of

From the Surgical Service of the Massachusetts General Hospital.

a fracture in the shaft of a long bone when the triangular ligament is not ruptured. The intact radio-ulnar joint serves as a fixed point around which to reconstruct the normal anatomy.

As the force continues backward and upward, displacement of the lower end of the radius becomes extreme and a disruption of the inferior radio-ulnar joint occurs. If displacement is marked, strain is exerted through the mediocarpal ligament and the discus interarticularis upon the ulnar styloid and this is frequently fractured. In other cases the ulnar attachment of the ligament gives way or the cartilage may be torn across. When general fragmentation of the lower end of the radius into the joint occurs, a similar disintegration of the joint takes place.

It is our contention that the successful management of Colles' fracture revolves around the integrity of the radio-ulnar joint which in turn depends upon an intact triangular ligament. If this is true, we may arbitrarily divide our group of Colles' fractures into two main groups:

1. Fractures with triangular ligament intact.
2. Fractures with loss of integrity of the radio-ulnar joint which may occur in one of three ways: (a) rupture of the ligament itself, (b) avulsion of the ulnar styloid at its base, (c) severe comminution of the lower end of the radius with the ligament remaining attached to a minor medial fragment.

FIRST GROUP

In the first group in order of severity are: (1) fractures of radial styloid, (2) simple epiphyseal separations, (3) simple transverse fractures.

The problem of anesthesia, reduction and fixation is essentially the same for the entire group.

Anesthesia. In general the members of the staff feel that complete anesthesia is necessary for manipulative reduction of these fractures. Ether has been the choice unless contra-indicated. Novocain, however, may readily be used in this group. After thorough preparation of the skin with iodine, 15 to 20 cubic centimeters of a 2 per cent solution of novocain is injected on the dorsum, preferably directly into the line of fracture. A definite interval should elapse before beginning the reduction. Recently a large group of fractures in this first group have been reduced in the emergency ward under intravenous evipal anesthesia with satisfactory results. Inasmuch as respiratory depression occasionally follows the use of evipal we have not employed it when there has been any question of skull injury.

Reduction. This group may satisfactorily be reduced without the aid of the fluoroscope. In general when the triangular ligament is intact the problem of reduction follows the general principles of: (1) breaking up the impaction by traction—adduction and abduction, (2) acute flexion with dorsal pressure on the distal fragment. Rarely is overcorrection obtained and once an adequate reduction is effected there is little tendency to recurrence. Adequate reduction requires that the impaction be broken up. Consequently, following reduction, the wrist should hang easily in flexion, crepitus must be obtained, and the normal landmarks re-established.

Fixation and after-care. Following the reduction simple anterior and posterior splints of molded plaster are sufficient. The patient is encouraged to move the fingers from the outset. The patient is observed at intervals during the first day to confirm the absence of circulatory disturbance in the hand. Pain calls for immediate revision of the apparatus. The splints are removed alternately to permit stroking and light massage after 2 days. Guarded active motions are begun after a week or 10 days. One splint is discarded after about 2 weeks and all splints are removed after about 3 weeks. Following removal of the splints, a simple wrist strap is advised for protection against extremes of motion. The patient is instructed in exercises to increase the extremes of active motion. Children may require a longer period of splinting than adults.

SECOND GROUP

When the integrity of the inferior radio-ulnar joint is lost through: (a) rupture of the triangular ligament, (b) avulsion of the base of the ulnar styloid, or (c) severe comminution of the radial articular surface, a much more complicated problem in treatment is presented. In the first group the problem is simply that of adequate reduction. In the more complicated cases of the second group there is now added the problem of maintenance of the reduction by proper fixation. It is by no means easy to obtain an adequate reduction in these cases, for there is no fixed point around which to build either the reduction or the fixation. Obviously the ordinary means of fixation used in simple transverse fractures will not suffice. When disintegration of the joint has taken place slipping of the fragments is all too common.

Anesthesia. In dealing with any joint fracture, it is of utmost importance to restore the normal anatomical relationship as completely as possible. Consequently, the reduction should be done under the fluoroscope, a general anesthetic being used, preferably ether. Unless there is a definite contra-indication to ether little brief is held for novocain anesthesia for these more complicated cases. Full

relaxation is essential and cannot be obtained uniformly with novocain injection. Attempts to do so have resulted in incomplete reductions requiring further reduction under a general anesthesia.

Reduction. The commonest defect of reduction was the failure to break up the impaction completely, with a consequent shortening of the radius and a backward tilt of the articular surface. This was most common in the group in which disintegration of the radio-ulnar joint had been unrecognized. Complete reduction requires that the radius must be restored to its full length with a proper forward tilt of the articular surface. At the same time the ulna must be restored to its dorsal position and brought into close apposition to the radius to prevent widening of the wrist.

Fixation. The most stable position will be found to be one of palmar flexion with extreme pronation and ulnar deviation, the so called Cotton-Loder position. If the ulna has been restored to its dorsal position, this maneuver wedges the cuneiform bone partly beneath the distal ulna, and prevents its forward luxation. This then gives stability to the ulnar side of the wrist, and continuance of the position to the extreme puts traction on the dorsal and lateral ligaments attaching to the fragments of the distal radius, thus helping to restore them to position by using the wedged ulna as a fulcrum. Continuance of ulnar deviation serves further to snug the radius up to the ulna and to permit reparative processes to reconstruct the ligamentary attachment. Maintenance of the position and complete immobilization is greatly facilitated by immobilization of the elbow which prevents any possibility of supination. Acute palmar flexion without pronation or ulnar deviation will not suffice to maintain the reduction. Maintenance of reduction and immobilization are accomplished by a plaster cylinder or preferably by the use of the so called sugar-tong splint made of a single strip of plaster.

AFTER-CARE

Some of the poor results are traceable to loss of reduction after it is secured. This may be due, in addition to the type of injury, to improperly fitting splints, to excessive padding, to failure to prevent elbow motion of pronation and supination, or to wilful tampering with the splints by irrational or unco-operative patients.

While it is probable that in some instances splints have been removed too early and that pain in an unsupported fracture has prevented or delayed proper return to function, we have been impressed by the extreme delay and disability in some arms splinted too long. The extreme Cotton-Loder position should not be maintained for longer than 10 days, for should fixation occur in this position it is the most useless of all functional positions. After 10 days the wrist is restored to the neutral position in anterior and posterior splints. The general program of removing the splints one at a time to permit massage is then followed. Disability usually lasts for 2 months. Any disability beyond that time is due either to improper reduction or maintenance of reduction, or to too prolonged splinting; or to failure of the patient to co-operate.

The poor results obtained in the treatment of Colles' fracture are in part due to the failure to recognize the fundamental difference in the problem in the two groups. Not only must each fracture be treated as an individual problem, but we must recognize that in the last group with disintegration of the joint or comminution into the joint possible failure results from the very nature of the injury.

FLEXION FRACTURES

Only 2 cases in the end-result series could be classed as flexion fractures. In these cases the distal radial fragment is displaced anteriorly. The fracture line may be either oblique or transverse. As has been pointed out by W. S. Wood, the transverse fractures may be reduced by closed reduction, provided the mechanism is recognized and the appropriate maneuvers are employed in reduction and fixation. Obviously, the reduction calls for hyperextension rather than flexion, and the splinting is in a cock-up position. It is doubtful whether the oblique fractures with anterior displacement can be satisfactorily maintained by any method of closed reduction and fixation. While it is probably worth while to attempt closed reduction, post reduction x-ray films should be studied and resort to operative interference should be prompt if closed methods prove inadequate. In our cases the condition probably was unrecognized and the fracture not properly reduced, and as a result the patients were left with deformity and residual disability. In a recent case of oblique flexion fracture the patient was treated by open reduction and internal fixation.

COMPOUND FRACTURES

Our series includes 4 cases of compound fracture. Their management involves the general principles applicable to compound fractures. Sepsis is extremely disastrous because the multiple joints and tendons may become involved. Immobilization in extreme position is avoided if possible. It may be necessary to neglect the fracture entirely and limit active treatment to the wound.

EPIPHYSEAL SEPARATION

Our series of end-result cases includes 22 instances of separation of the lower radial epiphysis. In nearly half of these cases there was a delay of a week or more before treatment was sought. Many of these patients, especially in the earlier years, were subjected to repeated manipulations and even to osteotomy to restore the epiphysis to its proper position. Since Aitken's excellent presentation of the satisfactory results of conservative measures, we have been less zealous in our attempts to secure anatomical reposition. Certainly osteotomy or attempt at operative restoration increases the likelihood of growth disturbance. For late deformity, due to cessation or distortion of growth, we have carried out the operation advocated by Darrach, Cotton, and others, with great satisfaction.

DELAY

Delay in reduction appeared as a significant cause of poor results in many of our cases. When the patients first present themselves a week or more after injury, the question is raised whether reduction should be attempted. The severity of the displacement and the age and social status of the patient must be evaluated. In general we have been unwilling to attempt closed reduction if more than 2 weeks have elapsed since injury. In such cases progress seems to be better if a regimen of early active motion is instituted at once. Many such patients were subjected to early osteotomy or other operative reductions but the results of these operations have not been particularly brilliant. This is in contrast to operations undertaken 6 months or a year after injury, after a period of active use, for the correction of a specific disability.

OPERATIVE TREATMENT

A few early fractures may require open reduction if closed reduction cannot be secured and maintained. However, it seems to us better in most cases to resort to early active motion and to defer operation until time has established the nature and extent of the disability or deformity. Marked backward angulation may be corrected by osteotomy. Excessive shortening may require resection of the ulnar head to restore proper carpal relations. Subluxation of the ulna, or permanent loss of the attachments of ulna and radius causes limitation and pain on pronation and supination. This condition can be greatly improved by resection of the distal end of the ulna. Attempts to repair or reconstruct the triangular ligament are less simple and less satisfactory.

SUMMARY OF END-RESULTS

End-result studies were made in 101 cases of fracture of the lower end of the radius, including 22 epiphyseal separations. It should be emphasized again that these are the complicated and more severe fractures from a total series of 870 cases. In 74 cases treatment was by closed reduction, and in 27 by operation, including the 4 compound fractures. Patients were observed at least a year after injury; those with epiphyseal injuries were usually followed many years.

In the group treated by closed reduction, 10 showed a poor anatomical result, as revealed by x-ray and clinical examination. Only 4 showed marked functional impairment and only 3 were seriously handicapped economically. It is noteworthy that functional results were often excellent even when late x-ray studies showed some persistent deformity. It is also noteworthy that all patients with excellent anatomical restoration presented also an excellent functional result.

In the group of 27 operative reductions and compound fractures, 10 showed poor anatomical reduction, 4 showed marked functional impairment, and 2 were seriously handicapped economically. Thus in the entire group, it may be said that 80 per cent presented a satisfactory anatomical end-result, 90 per cent presented good function, and only 5 per cent presented a serious economical handicap.

Detailed analysis of the poor results emphasizes the significance of the severity of the injury, delay before treatment, adequacy and maintenance of reduction, oversplinting, proper time and selection of operation, and the attitude of the patient. Flexion fractures and compound fractures rather obviously are more serious, and likely to give poor end-results. We wish to emphasize that fractures involving disintegration of the inferior radio-ulnar joint also constitute a more serious group, and that failure to recognize the complicating injury, or to effect and maintain adequate reduction is responsible for many of the poor end-results following the treatment of Colles' fracture.

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EDITORIALS

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AUGUST, 1938

ENDOMETRIOSIS—A POSSIBLE ETIOLOGICAL FACTOR

ENDOMETRIOSIS is the name given to ectopic endometrium wherever found in the pelvis, and endometrioma to the individual lesion. It never occurs above the pelvic brim but does in the umbilicus, the inguinal canal, the vulva, and occasionally in the vagina. The term adenomyoma is frequently used for the same lesion but preferably it should be confined to areas in the uterus which are just under the endometrial lining.

During the past year and a half the incidence of endometriosis in my private practice has been 16.7 per cent of all gynecological cases operated upon and 32.2 per cent of all abdominal gynecological cases. This editorial is an attempt to account for an apparent increase of this interesting pathological entity. A theory that may clarify the great incidence of this lesion is as follows: the more well to do patients seen in private practice have many years of menstruation before an interruption by pregnancy. This is due to late marriage, contraception, and spacing of children, which in turn are due to modern economic factors. The pathologist to the hospital, Dr. Tracy B. Mallory, has frequently remarked that the number of cases brought to his laboratory from private practice is much greater than the number from the general hospital practice. There are probably two reasons for this: (1), that certain surgeons interested in endometriosis send their pathological specimens to the pathologist well marked and that some surgeons find more specimens to send because of their diligent search for the disease; and (2), because the patients in the general hospital are of the type that marry early, have large families, and do not practice birth control. One other factor noticed in patients with endometriosis is the great number of patients with stigma of underdevelopment; for example, congenital erosion of the cervix, fibroids, dysmenorrhea, sterility, etc.

It is doubtful if the young female monkey, a menstruating animal in its natural habitat, has many periods before mating takes place and pregnancy begins. Following the birth of the young monkey the mother nurses her offspring, and at the end of the nursing period it is likely that another pregnancy begins. During the time of nursing it is probable that periods are not the rule, just as in the human. In other words, the number of menstrual periods of the female monkey is certainly smaller proportionately than in modern woman. During pregnancy and nursing the secretion of the hormones, estrin and progestin, is not the same as during normal menstruation. Therefore the customary rhythmic change in the endometrium and endometrium-like tissue is not present.

In older times when our feminine ancestors were interested in very little but the home and family, early marriages and large families were the rule and nearly all mothers nursed their offspring. Thus these women of former times more nearly approached the natural state of the only other species that has menstruation or rhythmic bleeding.

Without doubt endometriosis existed before John Sampson of Albany called our attention to it in 1921, but our older surgeons and gynecologists saw less of it before that time because the days of late marriages and spaced pregnancies had not arrived. It does not seem possible that men as able as our predecessors would not recognize and be concerned with such an entity if it were present in one third of all their pelvic operations. It is reasonable to assume then that the reason they did not recognize endometriosis is because it was not so common as it is now.

Two types of patients have endometriosis; those who are normal in every way except that marriage and especially pregnancy are delayed, and those who have stigma of pelvic underdevelopment. The latter often do not marry, and if they do, frequently do not conceive. Sampson's theory of a reflux of endometrium through the tubes is plausible but not so satisfactory as that of Iwanoff and Meyer who predicate a development of cells of the celomic epithelium, the predecessor of muellerian epithelium. If in certain patients genital underdevelopment is present, the prolonged stimulation of the underdeveloped tissues by a long uninterrupted menstrual career causes cells in the celomic epithelium to grow and to reproduce organs that they are concerned in developing. Inasmuch as the celomic epithelium is the precursor of the muellerian ducts which in turn precede the tubes, uterus, cervix, and the ovarian peritoneal covering is it not reasonable to assume that, under prolonged stimulation, left over cells of this tissue might commence to grow? Endometriosis is so widespread and is found in so many different parts of the pelvis that it is not reasonable to believe that it all comes through the tubes or metastasizes from the uterus. It cannot be denied that Sampson's theory explains certain cases well but it does not explain all cases of endometriosis as well as the theory of stimulation of the celomic epithelium. Witherspoon's idea of estrin stimulation being the causative agent is probably correct, but normal estrin stimulation would not produce the lesion. It is necessary to have a protracted stimulation without interruption in normal women or a normal or excessive stimulation upon an underdeveloped pelvic epithelium.

The theory advanced then is that women with a stigma of underdevelopment (and many of these do not marry because they are also underdeveloped sexually) and well developed women who put off marriage too long or who try to put off pregnancy until well after married life has begun are likely to develop endometriosis. It is therefore better that there be earlier marriages and that contraception be put off until at least one or two pregnancies have occurred. What is more pathetic than the girl who marries and for economic reasons can't have a baby, who later goes to her doctor with a sterility problem that cannot be solved?

Unquestionably it will be difficult to prove our concept, but an analysis of the cases of endometriosis seen in the last 100 abdominal operations gives suggestive support. In the résumé it is obvious that there are a few outstanding findings in support of the theory as follows: (1) The percentage of cases with stigma of underdevelopment of some part of the genital tract is large—75 per cent. (2) The percentage of patients without children

is great—43.7 per cent. (3) The use of methods of contraception is great—66.6 per cent. (4) The age of marriage is late, an average of 26.2 years. (5) The menstrual years per patient are many, all but one of the series having menstruated for 16 or more years before developing the lesion and all but 3 menstruating 10 years or more before the birth of the first child. Dr. Thomas R. Goethals, having reviewed the records of his private patients for the past year, finds that most primiparæ fall into two age groups—25 years and under and 26 years and over; 30 per cent are in the younger group and 70 per cent become pregnant the first time at or after the age of 26. It is obvious from his observation that there is a class of patients who are putting off pregnancy or at least who have not had the opportunity to become pregnant until the latter half of the third decade. It is this group that is courting endometriosis.

The argument then is as follows: menstruation, through the hormones estrin and progestin, causes a growth and functional change in the endometrium. This change, a preparation for pregnancy, should in a normal female be utilized. Monkeys surely have no such menstrual career as modern women, for mating and interruption of menstruation by pregnancy occurs early and frequently. In the modern woman, late marriage, contraception, and the like, allow a prolonged menstrual life without interruption. It is generally conceded that the peritoneal covering of the ovaries and uterus and the pelvic peritoneum are derived from the celomic epithelium. The muellerian ducts arise from the celomic epithelium and form the tubes, uterus, and cervix. In the course of such formation cells of muellerian epithelium and areas of primitive celomic epithelium may not be utilized. Under too prolonged and uninterrupted stimulation of the hormones, estrin and progestin, unutilized cells of the celom may become muellerian or uterine and thus produce endometriosis, while under even shorter stimulation the epithelium of the patient with stigma of underdevelopment may develop into endometriosis.

JOE VINCENT MEIGS

PLASTIC SURGERY IN GREAT BRITAIN

A SURVEY of plastic surgery in Great Britain is not without interest to those in the United States who either practice or intend to practice this somewhat vaguely delineated specialty. For many years plastic surgery has been what each individual surgeon made of it—a loose field, unsatisfactory in name, whose boundaries automatically established themselves by reason of the surgeon's own training, inclination, or opportunities. Thus we have dental surgeons and maxillofacial surgeons dealing with injuries, diseases, and malformations of the jaw, while others extend this field to include the treatment of almost any facial condition. A great many otorhinologists, laryngologists, and ophthalmologists undertake the plastic treatment of the nose, eyelids, and ears as part of their routine work. Then again there are general surgeons who are particularly interested in the treatment of cleft lip and palate, and the deformities of childhood. Others who call themselves cosmetic or esthetic surgeons are confined to the treatment of cosmetic disabilities and differ widely in intention, character, and ethical standards. Finally there are what might be termed constructive surgeons who concern themselves only with the repair of superficial body defects as opposed to the cure of the ravages of disease, and who carry their principles into effect from the scalp to the soles of the feet. The last named today represent the dominant type of plastic surgeon in Great

Britain. The purely constructive idea to a certain extent has spread to the continent, and is expressed in the suggestion that the specialty should in future be called "structive surgery." In our inelastic language there is no word which exactly translates this idea, "constructive" or "reparative" being admittedly inadequate substitutes. By common consent the term "plastic" with all its unwelcome associations would appear to be firmly established both in the lay and professional mind, and it is probable nothing else will supplant it.

The Great War undoubtedly gave plastic surgery its most substantial fillip, but it somewhat arbitrarily limited the field to maxillofacial repair. In many parts of the world it exists in this form today, and is regarded as an offshoot of otorhinolaryngology, or dental surgery. In Great Britain and in certain parts of the U. S. A., however, the past twenty years have seen a remarkable extension of the plastic field and a changing conception of its relationship to the other surgical specialties, and to surgery in general. This probably reflects the broader outlook of those surgeons who have been attracted to plastic work from general surgery rather than from other branches of medicine. Thus we find that the field includes the reconstructive and reparative surgery of a wide variety of congenital and acquired superficial defects, the cure of which necessitates a study of the principles of pure repair. Such a constructive ideal has much in common with the fundamentals of orthopedic surgery, and is in sharp contrast to the Hunterian opinion that operations in general are a tacit acknowledgment of the insufficiency of the healing art, in that they of necessity destroy in order to heal. It is an interesting commentary on modern trends of surgical thought that today an increasing number of surgeons are seriously concerned not with the cure of disease or the relief of physical pain, but with the repair of defects the majority of which will not shorten the patient's life by one minute nor give him a moment of physical pain. Their aim is to restore defects of physical appearance to that functional normality which will enable the sufferers to pass among their fellowmen without comment, to earn their living, to marry, and to become economic members of the community. The concept that surgery can be usefully employed for the relief of mental suffering is not new but it has taken overlong to gain a more general acceptance. The true plastic surgeon, however, does not confine himself to the treatment of minor cosmetic disabilities.

The quickening interest of the profession has been shown in a variety of ways. Two of the largest and most conservative teaching hospitals in London have established plastic departments, and the day may yet come when every teaching hospital has attached to its staff a surgeon capable of dealing with these problems. Thus the student may gain a first rate knowledge of the supreme importance of the fundamental principles of surgery. He can learn to appreciate the finer points of surgical craftsmanship, such as the virtue of gentleness in the handling of living tissue, of rigid asepsis, hemostasis, and accurate apposition without tension in wound suture. He may even be led to speculate upon the relationship between surgical trauma and the never ceasing wonder of the healing process, and why differences in technique can lead to such startlingly divergent results. Its value to the community has been demonstrated by the Plastic Unit established by the London County Council, by services in a variety of intermediate hospitals throughout London, and in the provinces, under the leadership of the Clinic in North Staffordshire, by others in Birmingham and in Manchester. It would be easy to visualize a service as efficient though possibly not so far

reaching as that carried on throughout the country by orthopedic surgeons. This specialty will develop in the future, but its progress as in the past will be slow, for it will probably appeal to the few—to those who have a love of craftsmanship and artistry, and to those who are willing to submit themselves to the arduous training of hand and eye necessary for its successful performance.

It is within memory that certain members of the profession looked askance at this struggling infant, judged it marasmic and prophesied for it a sickly adolescence and an early decline. It is safe to say, however, that in the face of much uninformed criticism reconstructive and reparative surgery is based on sound principles, amply fulfills the best Hunterian traditions, and is today firmly established. The widespread interest created by the Second European Congress of Plastic Surgery recently held in London showed conclusively that the time has come when this specialty may be regarded as completely divorced from the general surgical field. Its future would appear to be assured.

London, England. ARCHIBALD H. MCINDOE

MASTER SURGEONS OF AMERICA

FRANK DORMER JENNINGS

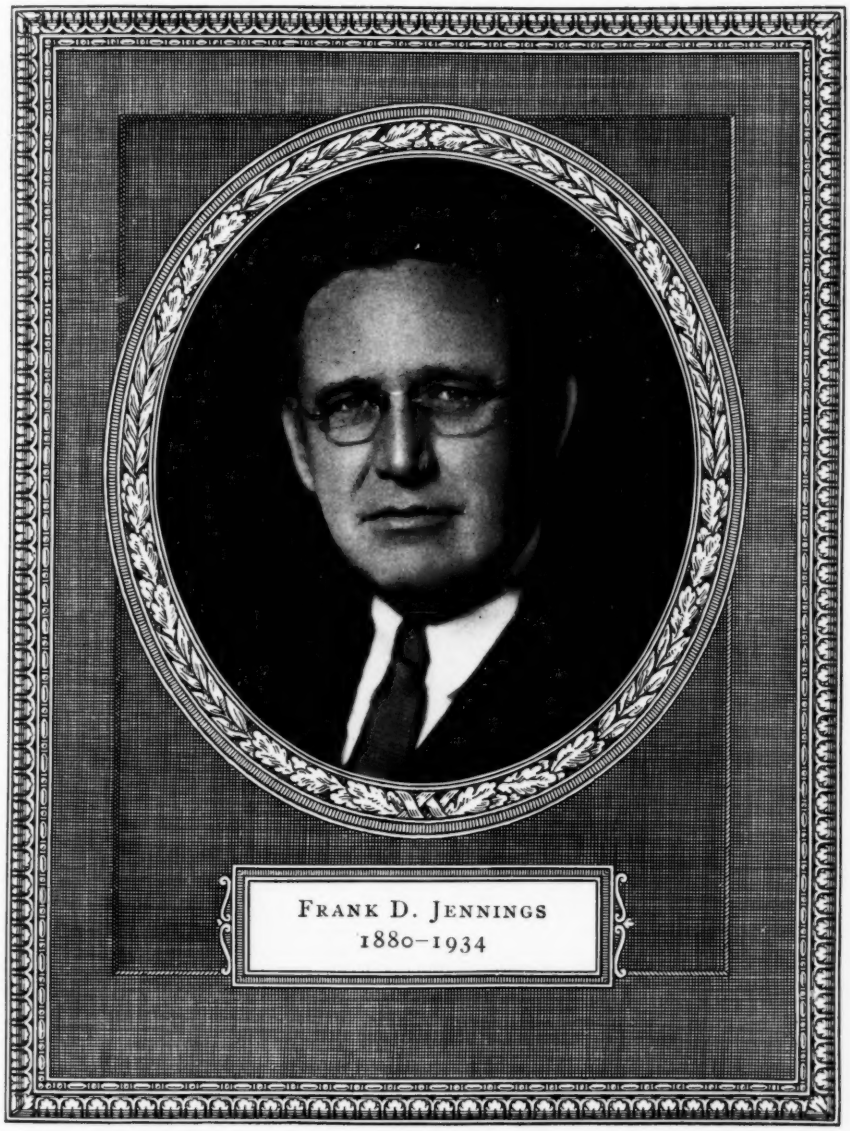
DURING his life Frank Dormer Jennings won a full measure of appreciation. Time but makes us more keenly aware of our loss. Loved and trusted by his fellow physicians in Brooklyn, because no man in the history of Brooklyn medicine ever did more for them, he was widely known about the country, too. Of distinguished presence, easy authority, and ready verbal rejoinder, he was thoroughly at home anywhere he happened to be. His knowledge of social and economic problems, his interest in legislation and sports multiplied his friends without end; with an unusually retentive memory, there were few subjects on which he could not discourse. A real leader with a vigorous and critical mind, decided views, and colorful personality he was an able surgeon and a fine citizen. A charming humanist, nothing in America was alien to him,

> "Whose power shed round him in the common strife,
> Or mild concerns of ordinary life,
> A constant influence, a peculiar grace."

Frank Dormer Jennings was born in Corning, New York, on June 19, 1880. His father, James N. Jennings, was born in Mt. Morris, New York, and his mother, Catherine Dormer, was a native of Corning. He was graduated from the Corning Free Academy in 1897, and from the College of Physicians and Surgeons, Columbia University in 1902. His interne years were passed at St. Catherine's Hospital, Brooklyn, where, after long apprenticeship, he later became attending surgeon; this was the only active hospital appointment he held at the time of his death, although he was still consulting surgeon to the Mary Immaculate Hospital, Greenpoint Hospital, and Menorah Home. At Greenpoint, a municipal hospital, he had been attending surgeon for over ten years. St. Catherine's, however, he called his workshop and he loved that hospital more than life itself; only a few hours before his death, he made his rounds in his usual painstaking way.

On October 27, 1913, he married Hannah Cecilia McCarthy. Three children, Frank, Catherine, and Joan blessed their very happy marriage. Catherine's untimely death took heavy toll of him. His devoted wife, Joan, and Frank, a student at the Long Island College of Medicine, survive him. A tender and understanding husband and father, he loved his home and family.

Master surgeon and keen diagnostician, wisdom, conservatism, good judgment, knowledge of the experience of others and frequent critical evaluation of



FRANK D. JENNINGS
1880–1934

his own work distinguished his surgery. Neither a spectacular nor a rapid operator, his work was characterized by thorough study of his patients, a fine knowledge of anatomy, attention to details, perfect technique and a gentle deliberateness in which every motion attained its purpose without loss of time.

A father to the young men about the hospital, he guided them, urged them to higher endeavor, and never tired of finding professional opportunities for them. Of unimpeachable integrity, the shining example of all that a surgeon should be, he trained his associates well. He insisted upon their attendance at medical meetings, membership in scientific societies and required of them constant watchfulness over their end-results. In his conferences with his associates, his hearty laughter tempered the sharp edge of his criticism.

Not a prolific writer, he made many important contributions to medical literature. His profound knowledge of hernia in all its phases grew out of his lifelong interest and wide experience in its management. He wrote well, as he talked, with clear incisive diction. The records of all his operations were written in his own clear characteristic hand. In the same way he recorded the progress of every patient. For many years his records have been an inspiration to the entire staff. All day long was nothing to him in his work in the public wards; he spared neither time nor pains in his work.

For ten years clinical professor of surgery at the Long Island College of Medicine, he was an exceptional teacher. Intensely practical, endowed with a vast fund of common sense, he possessed to an unusual degree the art of awakening the interest of his students. Intending to stimulate them to lifelong participation in the problems of organized medicine, he never failed to arouse in them a newly found sense of civic responsibility.

His great talent for organization found expression in the early years of the Catholic Hospital Association and in the American College of Surgeons. He gave freely of his time and energy to hospitals everywhere, for far and wide they asked him to address their staffs and discuss with them the new problems of standardization which, fifteen years ago, had suddenly become so momentous. He presided over hospital standardization conferences of the American College of Surgeons in Boston, Philadelphia and Chicago, and demonstrated for the College a model staff conference at its meeting in New York. He had brought the staff conference to Brooklyn, and, in his own hospitals, had molded its form and brought to it the courage, fair mindedness, and love of truth so characteristic of him.

When the Medical Society of the County of Kings celebrated its centenary in 1902 he was elected president, the highest honor that could come to any physician in Brooklyn. That venerable society was awakened to new life, for his capacity for work was tremendous and his enthusiasm was contagious. His inspiring leadership carried all with him, for his sincerity and vision were never

questioned. He widened the sphere of influence of the committee on public health and won a place for medicine in the discussion of civic problems; he set up a responsible reference committee for the press, and he made postgraduate education available to every doctor in Brooklyn without cost and without leaving home or practice. This he accomplished by means of a joint committee of the Medical Society and the Long Island College of Medicine. This plan has been in successful operation for fourteen years, and, known as the Brooklyn Idea, has found favor elsewhere. One of the first to arouse the medical profession to the importance of stemming the tide of ominous legislation which threatened to overwhelm us, in organized medicine he blazed a yeoman's path.

His activities were not restricted to the terrain of medicine. He continually pointed out that the physician must never forget his responsibilities and duties as a citizen. For himself he answered every call of civic organizations, and a great many demands were made upon him. As chairman of the Public Health Committee of the Brooklyn Chamber of Commerce his work was notable. Although he always complained that it was not an easy task, he was most at home making an after dinner speech, for he was never dull, and he loved a joke; his sallies were eagerly awaited by his audience. Absolutely at ease, he was always himself, never at a loss for words, and his perfect turning of points was always effective.

"For his lips could well pronounce
Words that were persuasions."

Even his triumph over the physical threat which hung over him was an inspiration to us all. Fear was not in him,—the habit of hard work was. On January 26, 1934 at the peak of his personal and professional prestige, he died in the harness of his beloved profession, as he would have wished, at his desk in his office. His death was typical of his service to the community.

"To live in hearts we leave behind
Is not to die."

CHARLES A. GORDON.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE second volume of the *Atlas of Pathological Anatomy*[1] issued under the direction of the editorial committee of the *British Journal of Surgery* and compiled by E. K. Martin in keeping with its predecessor, volume 1, presents a collection of illustrations of pathological conditions. The majority of the 250 to 300 figures are in colors, and since they are mainly executed by Sewell and a few by Maxwell and Terzi, their quality is excellent. The illustrations are well grouped into sections dealing either with systems such as the joints, or with organs, such as the thyroid or tongue. Especially interesting and valuable are those dealing with the pharynx and esophagus and with the genito-urinary system, particularly the testis. Each group of figures is preceded by a succinct description of the general pathological features of the special field, while each figure is accompanied by clinical and pathological description. The book provides a liberal education in special pathology and should serve as an excellent source book for illustrations not only of common but of rare pathological conditions. The publishers are to be congratulated on the excellency of their illustrations.

MICHAEL L. MASON.

THE author of *Hautdesinfektionsprobleme*[2] determines the efficacy of skin disinfection following the usual methods of surgical scrubbing and hand preparation. Cultures were made from the hands of some seventy physicians and nurses, from several scrub-women and a number of patients, before and after various methods of scrubbing and types of antiseptic baths. Bichloride of mercury solution, while the most powerful antiseptic, was also the most irritant to the skin and could not long be used. Phenosalyl, while not so irritating, was found to be less efficient, while soap spirits were found occasionally very efficient, but often irritant. The simpler method of surgical scrubbing with soap for 6 minutes, followed by 4 minutes of soaking in 90 per cent (not 70 per cent) alcohol, appeared to yield fairly consistent and satisfactory results. The author does not draw any very definite conclusions, nor does he make any specific recommendations concerning methods of preparing the hands for surgery, but one is left with the impression that he favors a brief scrubbing with soap and water, followed by 4 to 6 minutes of soaking in 90 per cent alcohol.

No attempt is made to correlate the findings with any clinical data or to evaluate the significance of positive cultures taken from the skin. In none of the methods used were sterile hands always obtained and we must conclude that the same situation obtains in any of the usual methods of hand preparation. Such observations serve to emphasize again the fact that sterility of the operative field is relative and that what matters most is that the number of bacteria be not too great, nor their virulence too high, and that the host's resistance is not too badly interfered with. MICHAEL L. MASON.

AS IN previous years *The Year Book of Radiology*[3] provides the medical profession with abstracts of the most significant contributions to the year's literature. The material used has been well selected and includes many contributions from foreign countries. The editorial comments are concise and greatly enhance the value of the volume.

Naturally, not all of the material is completely new but one cannot help but note the newer concepts and methods as well as the expansion of the field of roentgenology. The correlation of clinical knowledge with roentgen interpretation becomes more and more important as the scope of the specialty broadens.

The use of contrast materials has become more widespread so that almost all body cavities have been visualized. Mammography and the demonstration of rupture of the intervertebral disc into the spinal canal after lipiodol injection are among the newer methods.

It is impossible, of course, adequately to review a volume of this type. Suffice it to say that all divisions of roentgenologic diagnosis—osseous, glandular, respiratory, cardiovascular, gastro-intestinal, genito-urinary, obstetrics, gynecology, and nervous system—are adequately covered in a most interesting manner.

Kaplan begins the section of radiotherapeutics with a discussion of the cancer problem as a whole. This is followed by chapters dealing with radiation biology and physics. The division of the material into the various specialties makes it particularly valuable as a reference volume. As was noted in diagnosis, the field of radiotherapeutics is expanding. The beneficial effect of radiation on inflammatory tissue can no longer be doubted. Supervoltage x-ray therapy has not as yet proved to be of sufficient value to warrant universal use and the enormous expense of installation.

[1] ATLAS OF PATHOLOGICAL ANATOMY; ISSUED UNDER THE DIRECTION OF THE EDITORIAL COMMITTEE OF THE BRITISH JOURNAL OF SURGERY. Compiled by I. K. Martin, M.S., F.R.C.S. Vol. 2. Baltimore: William Wood & Co., 1935.

[2] HAUTDESINFEKTIONSPROBLEME. By Jörgen Ernst. Copenhagen: Levin & Munksgaard, Ejnar Munksgaard 1937.

[3] THE 1937 YEAR BOOK OF RADIOLOGY. DIAGNOSIS. Edited by Charles A. Waters, M.D. Associate editor, Whitmer B. Firor, M.D. THERAPEUTICS. Edited by Ira I. Kaplan, B.Sc., M.D. Chicago: The Year Book Publishers, Inc., 1937.

The Year Book of Radiology has established itself as a valuable addition to the library of anyone interested in roentgenology. It is used by the reviewer regularly and is recommended without reservation. EARL E. BARTH.

WARM praise should be given to *The Roentgenologist in Court*[1] a book which is very comprehensive yet easy to read. Lawyers, as well as physicians, should find in it a mine of information and a helpful guide in the preparation and conduction of medicolegal cases. The reviewer has consulted a number of leading attorneys who agree that the work, especially chapters 4, 7, 9, 10 and 13, cover the fundamental principles which lawyers and doctors as a class sometimes do not readily understand. Chapter 13, "Doctor, take the stand," is most impressive; if physicians would read this chapter they would get over the mental hazard which is explained so well. Malpractice actions are on the increase. Many of them are based on the false economy which led the physician first handling the injury case to dispense with x-ray studies. Repeated decisions affirm that the use of x-rays is mandatory in the treatment of fractures. An important chapter concerns prophylaxis against malpractice suits. The purchase of this book would be a wise investment for any physician.

JAMES T. CASE.

IN HIS book regarding genito-urinary abnormalities, Dr. Young[2] presents his experiences in a most interesting field of medicine. These experiences are unique and are probably unequaled by anyone in this particular field. It is difficult to conceive of one man's having amassed such an extremely interesting, and yet diverse, group of cases during his professional career.

With his usual painstaking care and meticulous attention to detail, Dr. Young has given us one of the most interesting and valuable books that has been published for many years.

The subject of hermaphroditism is presented in an elaborate manner; in fact it may be said that Dr. Young's presentation is classic. Before discussing the subject of hermaphroditism proper, the author has, quite correctly and in detail, presented a chapter on the embryology of this condition. The subject is presented in four chapters that deal with pseudohermaphroditism, female pseudohermaphroditism, true hermaphroditism, and hermaphroditism with the sex undetermined. Case histories, illustrations of patients, and illustrations of the various operative procedures are given with great care.

An interesting and instructive chapter is the one that deals with vaginal abnormalities in hermaphroditism. The chapters dealing with adrenogenital syndrome, prostates in females, and hypogenitalism and hypergenitalism are given in a masterful fashion. Some of the more common malformations of the urinary tract, such as hypospadias, epispadias, exstrophy of the bladder, and congenital valves in the prostatic urethra, are also included.

The final chapter deals with the relationship of the genital tract to the endocrine glands, and a discussion of endocrine therapy is given.

This book will serve as a standard reference for many years to come, not only for the urologist but also for the gynecologist, the general surgeon, the pediatrician, the endocrinologist, and the embryologist.

The text is beautifully and profusely illustrated and no attempt has been spared in the way of illustrations, of which there are more than five hundred.

HERMAN L. KRETSCHMER.

THE sixth edition of *The Science and Practice of Surgery* by Romanis and Mitchiner[3] is now available. It is a comparatively new work, the first edition appearing in 1927, and since this is the sixth edition, it would seem that the authors are giving the work adequate attention so that it may be an accurate expression of the ever advancing science of surgery. Numerous additions and alterations may be found in the new edition in comparison to the fifth which appeared in 1934. Noteworthy are the revisions of the chapters on fractures and dislocations, x-ray and radiation therapy, anesthesia, and genito-urinary disease. The section on the sympathetic nervous system has been completely rewritten. It has been the privilege of the reviewer to watch this work pass through its various editions and revisions and to note how thoroughly the material is being checked. Errors and misstatements will creep into any work of the magnitude of this system which consists of approximately 1800 pages, moreover differences of opinion will be ever present. Such differences of opinion are a stimulant to progress and reflect a healthy state of the profession.

This work is comprehensive, and although the information given on any one topic of necessity is limited in scope, a tremendous amount of material is accumulated in a concise form. Specific details in treatment are often lacking and vague and for that reason the inexperienced reader may be misled at times. It is true that to complete all surgical subjects would require an almost endless amount of book space. There may be found, however, statements which are questioned. In describing the treatment of peritonitis with excessive vomiting, the authors state: "the absence of which (bile) from the cæcum is a potent cause of paralytic ileus." Further along it is stated: "A jejunostomy may be performed and the bowel washed with warm sterile saline with advantage." For the treatment of acute

[1] THE ROENTGENOLOGIST IN COURT. By Samuel Wright Donaldson, A.B., M.D., F.A.C.R. Springfield, Ill., and Baltimore, Md.: Charles C. Thomas, 1937.

[2] GENITAL ABNORMALITIES, HERMAPHRODITISM, AND RELATED ADRENAL DISEASES. By Hugh Hampton Young, M.A., M.D., Sc.D., F.R.C.S.I., D.S.M. Baltimore: The Williams & Wilkins Co., 1937.

[3] THE SCIENCE AND PRACTICE OF SURGERY. By W. H. C. Romanis, M.A., M.B., M.Ch. (Cantab.), F.R.C.S. (Eng.), F.R.S. (Edin.), and Philip H. Mitchiner, M.D., M. S. (Lond.), F.R.C.S. (Eng.). 6th ed. Vols. 1 and 2. London: J. & A. Churchill, Ltd., 1937.

gonococcal salpingitis it is recommended: "This consists of laparotomy, squeezing out the pus from the inflamed tubes which should not be removed, and mopping out the pelvis with sterile plugs." Attention is called to such statements in the hope of stimulating thought upon the subjects, since the conclusions are at variance with the consensus in the United States. It is noted that no great stress is placed upon intestinal decompression by tube, and an accurate control of water and blood chloride balance in the treatment of intestinal obstruction. In the States the treatment of intestinal obstruction is summed up by Wangensteen as follows: saline solution, blood transfusion, decompression by tube and operation. Transurethral electric resection of the prostate is not mentioned, although reference is made to the excision of wedge-shaped portions of the prostate.

The chief value of this system, from the reviewer's viewpoint, is that here are assembled brief descriptions of practically all the surgical conditions known to man. For the student, therefore, it is a valuable reference work. JOHN A. WOLFER.

BY FAR the best and clearest statement of Pavlov's experiments, observations, and ideas pertaining to conditional reflexes and experimental neurosis that has been made available is contained in the book, *Pavlov and His School*.[1] The method of presentation and mode of expression are delightful. The photographs and illustrations are very helpful in elucidating a complex subject. The book reads easily and the biographical sketch of Pavlov and, in fact, the entire book is truly fascinating and inspirational.

Every medical student, biologist, and physician should read the book. To one who has had any contact with science, this book will prove to be more pleasant literature than the best novel, analytical story, or adventure tale. A. C. IVY.

THE second volume of Duke-Elder's *Textbook of Ophthalmology*[2] has been published—Volume 1, the Development, Form and Function of the Visual Apparatus, was published in 1936. Those familiar with the first volume have awaited the appearance of volume 2 with great interest and, although they appreciate the tremendous task involved, hope that the succeeding volumes will appear shortly.

As stated in the preface of the first volume, the author's purpose is to make available in the literature, a reference textbook of ophthalmology. This he has certainly done. A brief historical sketch of a pre-eminent figure in the field to be discussed is given and the presentation of the subject matter is straightforward, concise, yet adequate. Both sides of controversial questions are presented and the author gives his own viewpoints with his reasons for them. An inclusive up-to-date bibliography is included for each topic. A wealth of easily accessible material is contained in the volume; not only is each topic thoroughly discussed, but topics which in the ordinary text are merely mentioned, here are fully treated. Perusal of volumes 1 and 2 gives convincing proof that with the volumes yet to come the field of ophthalmology will be fully and thoroughly covered by Sir W. Steward Duke-Elder.

This *Textbook of Ophthalmology* is to be highly recommended. WILLIAM H. DROEGEMUELLER.

[1] PAVLOV AND HIS SCHOOL; THE THEORY OF CONDITIONED REFLEXES. By Prof. Y. P. Frolov, M.D. Translated from the Russian by C. P. Dutt, B.A. (Cantab.). New York: Oxford University Press, 1937.

[2] TEXTBOOK OF OPHTHALMOLOGY. By Sir W. Steward Duke-Elder, M.A., D.Sc. (St. And.), Ph.D. (Lond.), M.D., Ch.B., F.R.C.S. Vol. 2—Clinical Methods of Examination, Congenital and Developmental Anomalies, General Pathological and Therapeutic Considerations, Diseases of the Outer Eye. St. Louis: C. V. Mosby Co., 1938.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

INDUSTRIAL SURGERY; PRINCIPLES, PROBLEMS, AND PRACTICE. By Willis W. Lasher, M.D., F.A.C.S. New York: Paul B. Hoeber, Inc., 1938.

NEW AND NONOFFICIAL REMEDIES, 1938. Containing Descriptions of the Articles Which Stand Accepted by the Council on Pharmacy and Chemistry of the American Medical Association on January 1, 1938. Chicago: American Medical Association, 1938.

ANNUAL REPRINT OF THE REPORTS OF THE COUNCIL ON PHARMACY AND CHEMISTRY OF THE AMERICAN MEDICAL ASSOCIATION FOR 1937 WITH THE COMMENTS THAT HAVE APPEARED IN THE JOURNAL. Chicago: American Medical Association, 1938.

A SYNOPSIS OF THE DIAGNOSIS OF THE ACUTE SURGICAL DISEASES OF THE ABDOMEN. By John A. Hardy, B.Sc., M.D., F.A.C.S. St. Louis: The C. V. Mosby Co., 1938.

ASSOCIATION FOR RESEARCH IN NERVOUS AND MENTAL DISEASE. Vol. XVII of a Series of Research Publications. THE PITUITARY GLAND; AN INVESTIGATION OF THE MOST RECENT ADVANCES. The Proceedings of the Association, New York, December 28th and 29th, 1936. Editorial Board: Walter Timme, Angus M. Frantz, Clarence C. Hare. Baltimore: The Williams & Wilkins Co., 1938.

MEDIZINISCHE PRAXIS; SAMMLUNG FUER AERZTLICHE FORTBILDUNG. Edited by L. R. Grote, A. Fromme, and K. Warnekros. Vol. 9—BLUTUNG UND FLUOR. By Prof. Dr. Hans Runge. Dresden and Leipzig: Theodor Steinkopff, 1938.

MATERNAL CARE COMPLICATIONS; THE PRINCIPLES OF MANAGEMENT OF SOME SERIOUS COMPLICATIONS ARISING DURING THE ANTEPARTUM, INTRAPARTUM, AND POSTPARTUM PERIODS. Approved by The American Committee on Maternal Welfare, Inc. Prepared by R. D. Mussey, M.D., P. F. Williams, M.D., and F. H. Falls, M.D. F. L. Adair, M.D., Editor. Chicago, Ill.: The University of Chicago Press, 1938.

ELECTROTHERAPY AND LIGHT THERAPY. By Richard Kovács, M.D. 3d rev. ed. Philadelphia: Lea & Febiger, 1938.

SURFACE AND RADIOLOGICAL ANATOMY; FOR STUDENTS AND GENERAL PRACTITIONERS. By Arthur B. Appleton, M.A., M.D.(Cantab.), William J. Hamilton, M.D., B.Ch.(Belf.), D.Sc.(Glas.), F.R.S.E., and Ivan C. C. Tchaperoff, M.A., M.D., B.Ch.(Cantab.), D.M.R.E. Baltimore: William Wood & Co., 1938.

CORRESPONDENCE

THE DANGER OF THE INTRAVENOUS "DRIP"

To the Editor: For several years I have been inveighing against the use of the "drip" apparatus in intravenous injections. The "drip" device, which permits counting the drops, has no really useful function and is dangerous. The rate of flow of the fluid into the vein can be much better determined by placing a little strip of adhesive plaster at the level of the fluid in a graduated glass container and noting the amount of fluid that has gone into the vein within a definite period of time. The flow can then be regulated by a thumbscrew clamp on the rubber tube.

The objections to the "drip" device are:

1. It is unnecessary and complicating.

2. The rate of flow can be even more accurately ascertained by the method mentioned, for drops are not always of the same size.

3. There is a distinct danger of air embolus. When the patient is straining or vomiting the pressure in the veins is high and the back pressure on the drip device compresses the air in it. When the straining suddenly ceases and the flow through the intravenous needle or cannula becomes rapid, air may be sucked over into the veins. Often this is of no great importance, but it seems probable that those who have reported a large incidence of pulmonary emboli and thrombi following intravenous injections will find it due chiefly to this drip method. The air may form a nucleus for a thrombus.

In this connection the report of a necropsy by Dr. K. L. Terplan before the Buffalo Pathological Society[1] is interesting. It is as follows.

"A 2 year old white girl known to have been suffering from congenital heart disease became severely ill with pneumonia, hemorrhagic pleuritis, and erysipelas. The general condition of the child was very poor. After an intravenous drip of 5 per cent dextrose solution had been concluded, the child died suddenly. The attending pediatrician expected an embolic cause for the sudden death.

"In this case all the air was trapped completely in the main stem of the pulmonary artery, which contained typical pinkish white foam but neither fluid blood nor clots. There was a distinct fusiform distention of the main stem of the pulmonary artery. The right ventricle and the right atrium contained only fluid blood and a few thin clots. (The postmortem examination was performed about 7 hours after death.) In the major branches of the pulmonary artery there was mostly fluid blood with hardly any foam.

"An apparently small amount of air had sufficed to bring about immediate death in a child suffering from effusion in the left pleural cavity, marked pressure atelectasis and diffuse bronchopneumonia of the right lung."

J. SHELTON HORSLEY

Richmond, Virginia

[1] Tr., Arch. Pathol., 1936, 22:716.

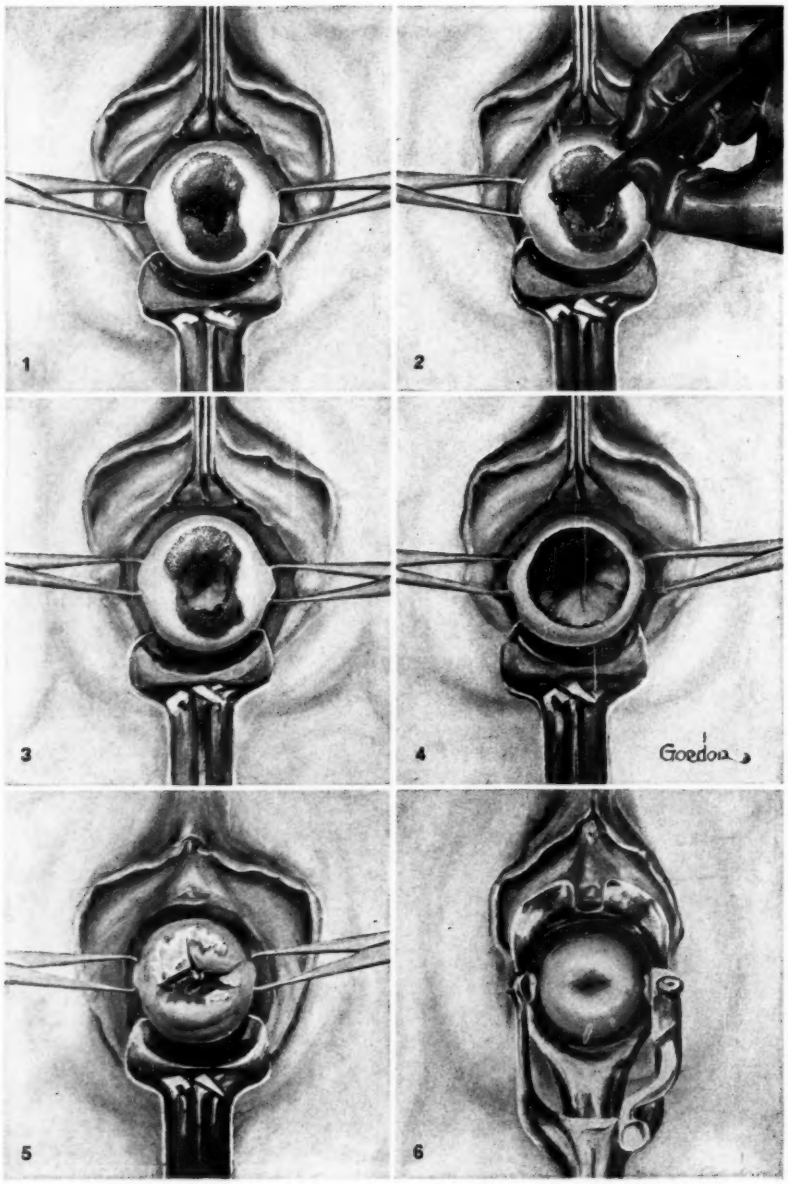


PLATE I. *1*, Erosion of the cervix. *2*, *3*, *4*, Illustrating technique. Depth and amount of tissue removed may be regulated as required. *5*, Cervix three weeks after conization. *6*, Cervix six weeks after.

Conization of the Cervix.—Norman F. Miller and Oliver E. Todd.